PD-AAQ-654

UNCLASSIFIED
CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) – PART I

Report Symbol U-447

1. PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
RURAL POTABLE WATER SUBPROJECT	664-0312.7	USAID/TUNIS

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY) 664-84-2

[XX] REGULAR EVALUATION [ ] SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES	6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY 80 B. Final Obligation Expected FY 80 C. Final Input Delivery FY 85	A. Total $ 3078 B. U.S. $ 2190	From (month/yr.) 7/80 To (month/yr.) 9/83 Date of Evaluation Review 1-11-84

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
Personnel/Management		
Hire additional personnel (sociologist) to strengthen CTDA Planning Unit Directorate capacity to conduct socio-demographic analysis for site selection.	PDG/CTDA	7/84
Hire short term TA to (a) study feasibility of creating water users associations, (b) assess role local beneficiaries prepared to play at spring and motorized sites and (c) revise/improve site selection procedure including questionnaires based on experience to date.	PDG/CTDA; Planning Unit; USAID & CTDA Project Mgrs.	5/84
Health Education		
Organize joint CTDA-GR-Governorate site maintenance and health education training in each of three Governorates.	CTDA Proj.Mgr. w.MinHealth,Educ. Governorate,GR.	a. organize 5/8 b. implement 5-
Maintenance Plans		
Secure written GR and Governorate approval of site specific maintenance plans for motorized sites as sites are completed.	CTDA Proj.Mgr.	As sites are c
Drilling Rig		
Review evaluation recommendations with RSH and DRES; determine which will be adopted, how and when.	CTDA (Proj.Mgr. PDG, USAID)	3/31/84
Order air-down-the-hole hammer, accessories, and TA for TH-60. Test air hammer and report results (comparative study drills bits vs. air hammer)	RSH-Director USAID Proj.Mgr.	a. order: 11/8 b. Test: 3/84
Up-date TH-60 and other (Failing 2000, Franks 2000) subproject drill rig performances and review results with RSH, DRES.	CTDA Proj.Mgr. USAID Proj.Mgr.	a. update: 3/8 b. review 5/84
Develop proposal for post-subproject management and use of TH-60 in Central Tunisia.	PDG/CTDA	5/84

(Cont'd)

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

- [ ] Project Paper
- [XX] Implementation Plan e.g., CPI Network
- [ ] Other (Specify)
- [ ] Financial Plan
- [ ] PIO/T
- [ ] Logical Framework
- [ ] PIO/C
- [ ] Other (Specify)
- [ ] Project Agreement
- [ ] PIO/P

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. [ ] Continue Project Without Change
- B. [ ] Change Project Design and/or [ ] Change Implementation Plan
- C. [ ] Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

DYoung, USAID/RD
Ridha El Fekih, PDG, CTDA
Moncef Hossein, CTDA

12. Mission/AID/W Office Director Approval

Signature

Typed Name: James R. Phippard

Date: 3-1-84

AID 1330-15 (3-78)

CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) – PART I

Report Symbol U-447

1. PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
RURAL POTABLE WATER SUBPORJECT	864-0312.7	USAID/TUNIS

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY) _____

xx ☒ REGULAR EVALUATION ☐ SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES	6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY____ B. Final Obligation Expected FY____ C. Final Input Delivery FY____	A. Total $ _____ B. U.S. $ _____	From (month/yr.) _____ To (month/yr.) _____ Date of Evaluation Review

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
Cont'd		
Civil works Replace contractor(s) with inadequate (unreasonable delays, poor quality work) performance.	CTDA Proj.Mgr.	1/84
Determine which evaluation recommendations will be adopted and implemented and obtain USAID Regional Engineer's concurrence.	CTDA Proj.Mgr. USAID Reg.Eng.	a. CTDA: 1/84 b. Reng.: 3/84
Other		
Revise Implementation Plan; extend PACD.	CTDA Proj.Mgr.; USAID	by 3/31/84

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

- ☐ Project Paper
- ☐ Financial Plan
- ☐ Logical Framework
- ☐ Project Agreement
- ☐ Implementation Plan e.g., CPI Network
- ☐ PIO/T
- ☐ PIO/C
- ☐ PIO/P
- ☐ Other (Specify) _____
- ☐ Other (Specify) _____

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. ☐ Continue Project Without Change
- B. ☐ Change Project Design and/or ☐ Change Implementation Plan
- C. ☐ Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

12. Mission/AID/W Office Director Approval

Signature

Typed Name

Date

AID 1330-15 (3-78)

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13. SUMMARY

1. The subproject has so far done a creditable job of expanding the access of the rural population to potable water at a reasonable cost. Its improvements are generally appreciated and eagerly awaited.

2. Drilled wells, although relatively costly and demanding in terms of post-construction maintenance and operating costs, provide the best way of increasing the access of rural populations to domestic water. See para 17-1 below.

3. Hand dug wells are the least costly method per capita of water supply development. More than 10 hand-dug wells may be financed for the cost of a single drilled well.

4. Drilling costs experienced with the AID-financed TH-60 drilling rig are in line with drilling costs elsewhere and the TH-60 performs better than conventional mud-rotary drilling rigs operated in Tunisia. However, all parties should consider using the TH-60 for reconnaissance, drilling with an air hammer, and drilling smaller bore holes.

5. Coordination between the different services of the Tunisian government should be improved to (a) put site specific maintenance and health education plans into operation, (b) reduce the competition between irrigation and domestic uses of water and (c) promote the participation of the beneficiaries.

6. The CTDA should recruit new staff with sociological expertise to evaluate the new social situations created by their interventions and recommend courses of action.

14. EVALUATION METHODOLOGY

The purpose of this evaluation was to measure the progress accomplished in the Central Tunisia Potable Water Project. To this end the evaluation team followed the scope of work and the log frame.The team members were:

Dr. Nicholas S. Hopkins, Professor of Anthropology, The American University of Cairo, Egypt (socio-economist and team leader);
M. Mohamed Ben Ali Mogadi, Direction du Genie Rural, Tunis (representing the Tunisian government and focusing on civil engineering and management issues).
Dr. William Turner, American Ground Water Consultants, Albuquerque, NM (hydrogeologist and drilling specialist).

The team began its work on September 2, 1983 in Tunis and concluded the in-country portion of its work on September 26, 1983. The team spent approximately two weeks in Central Tunisia visiting sites, interviewing Tunisian government officials and beneficiaries, and discussing its observations.

The team concentrated its efforts on Kasserine. This reflected a decision to focus on the governorate in which there were the most accomplishments to date.

15. EXTERNAL FACTORS

There appear to be no major changes in project setting that need to be taken into account at the moment. The project assumptions appear to have given insufficient attention to the potential confict that could arise between water use for domestic and irrigation purposes once new resources were created.

16. INPUTS

The project has been consistently running behind schedule. The reasons for the delays are numerous:

1.Technical and managerial problems with the drilling.

2.Institutional conflicts and technical problems in choosing the sites for the interventions (earlier in the program).

3.Inexperienced civil works contractors who underestimated costs and whose performance was inadequate.

4. The length of tune to complete motorized sites was underestimated by project planners. For example, the motor cannot be ordered until the technical specifications of the site are known, and then there are frequent technical difficulties in getting the right motor in place on the site.

5. The GR and Governorate did not identify and train pump operators/guards promptly as motorized sites were completed.

6. The CTDA, GR, and Governorate failed to develop site-specific maintenance plans which are required by USAID before reimbursing the CTDA for the costs of the interventions.

7. Although a general plan for health education and sanitation was developed and adopted fairly early in the history of the project, site specific plans have not been implemented. The Kasserine office for Health Education attributed this to their lack of vehicles to move their personnel to the countryside.

8. Although there was some consultation with local political representatives and population at the time of site selection, there appears to have been insufficient contact since then.

17. OUTPUTS

1. The original subproject construction output goal was to complete 160 sites (60 springs, 10 hand dug wells, 90 drilled wells). These objectives had to be revised downwards to 48 sites (18, 14 and 16 respectively) as (a) there is a limited number of springs to be developed in the project area and among these only a small number met the subproject site selection criteria and (b) the cost of well drilling was grossly underestimated in the Subproject Paper. The latter miscalculation was due in part to the fact that the company which in the project preparation stage provided a low drilling cost estimate was uninterested in providing drilling services in the project implementation stage.

Subproject drilled wells (depths of 128-200 meters), while more costly than subproject hand-dug wells (8-50 meters), are the best way of improving the rural populations' access to potable water where the acquifer is too deep to make hand-dug wells feasible. Moreover, drilled wells are unlikely to be exposed to surface contamination due to their depth and the fact that they have always been closed. Surface wells improved by the subproject were previously open systems. A third advantage of drilled wells is that their yields tend to be higher than surface well yields and often greater than the domestic water needs of the population within a 4 km radius of the water point. This enables the GOT to tap into drilled well system and distibute water to schools and communities located either within the 4km radius or at greater distances.

Drilling of new wells and the implementation of civil works to improve spring and surface wells began in the summer of 1982; 5 springs and 5 drilled wells were completed as of March 1983. Many interventions were largely completed. Several more shallow wells were ready for motor installation, but the motors had not yet been delivered. The same was true of some of the drilled wells. In other cases, the contractor had not quite finished working on the civil constructions. It is likely that the number of completed interventions will grow rapidly in the coming months.

2. To introduce a new technology for drilling relatively shallow wells suitable for the small numbers of a dispersed population, a medium-sized drilling rig (the Ingersoll-Rand TH-60) and 6 months technical assistance by two different drilling specialists were grant-financed under the subproject. The rig was put into operation in June 1982, and has since drilled several wells, including two "dry" holes.

3. Efforts to introduce a more systematic approach to site selection and to promote coordination among the various institutions involved in water and sanitation services have been only partially successful.

The staff at the CTDA are aware of the difference between their approach to site selection and that followed by other agencies, e.g. the Genie Rural and the CTDA is committed to applying the new methodology to all CTDA potable water projects. They argue that in contrast to the GR's tendency to react to pressing demands made by rural populations .The CTDA actively seeks out areas and sectors that are in need of water. They did this by identifying sectors where there was a demonstrable need for potable water.

In accordance with the loan agreement, the CTDA created a set of three maps; however, detailed hydrogeological resources maps are kept only by the DRES and hence separately from the other two. Moreover, the demographic information is hard to come by in any detail. Thus the method followed represents something of an innovation and respects the broad outlines of the water policy, but the degree of change does not match that expected.

In general, one might say that the emphasis has been on completing the physical interventions. CTDA concern with managerial aspects and any new patterns of social relations has been secondary and somewhat neglected. The same is true of participation by the beneficiaries in the program. This selective concentration is due partly to natural predelictions on the part of the CTDA, and partly to the sheer amount of work involved in completing the physical interventions. The subproject manager, along with other CTDA staff was provided with AID-financed project management training in 1982-83 and his performance has improved. However, due to the lack of staff and training in community development type work and the press of work in supervising the construction phase, it is not surprising that these concerns have been neglected.

4. Increased participation of populations in decisions concerning their own fate was intended to be one of the outputs of the subproject. The first problem in organizing or eliciting participation is determining the group that is involved, and this can be complicated in the case of Central Tunisia as there are no "villages" or other visible communities on the ground.

An alternative is to create special interest groups around well-defined resources. The evaluation team recommends the creation of water users associations.

18. PURPOSE

The project purposes are (1) to improve the access of the dispersed poor in the CTRD project area to potable water; (2) to encourage the CTDA to apply a rational policy for siting, designing and maintaining rural potable water systems; and (3) to test and demonstrate in Central Tunisia lower-cost technologies for providing potable water to dispersed populations.

The first purpose seems sure to be achieved, though the numbers affected may have to be recalculated. The initial documentation was based on a figure of 160 water points to benefit an average of 500 people or a total of 80,000 people. The actual project implementation involves 48 water points; using the same average figure for the beneficiaries the total population concerned would be 24,000; but it is likely that the average is at least twice as much. NOTE: Based on pre-implementation demographic surveys, the estimated number of beneficiaries for the 48 sites is 60,000 and their animals.

The second purpose has been only partially achieved. A more "rational" policy was followed in the site selection. The problem is less with the philosophy behind the policy and more with the practical difficulties with implementing it--getting adequate data, having sociologically aware people with a field orientation to inspect and analyze the sites ahead of time, making sure that socio-economic factors weigh at least as heavily as technical ones in site selection.

The lower-cost technologies have been demonstrated to some extent in Central Tunisia. In particular, the Ingersoll-Rand TH-60 drilling rig has attracted a lot of attention at the regional and national levels.

19. GOAL/SUBGOAL

The project goal is "Improved quality of life in the CTRD program area." Two indices of this are given: (1) to bring the morbidity rate down to the present national average; and (2) to reduce the time required by women and children to haul water for domestic uses. The effects of the project are still on a small enough scale to preclude the use of morbidity figures drawn from official sources. The results of the users survey given in Appendix A provides some information on both points. The data on morbidity rates should probably not to be taken too seriously since it relies on individuals' self-diagnosis and was collected at a relatively unhealthy time of year (end of the dry summer season). The data on time savings is somewhat more reliable. The real beneficiaries will be those living near the newly created water points, followed by those living in the catchment areas of improved dug wells.

20. BENEFICIARIES

The clearest beneficiaries are those living within a four-kilometer radius of the new drilled wells. In many cases, the entry into operation of these wells will permit people to shorten considerably the distance they must travel for water . This effect will be enhanced in the case of a site like Um Fadgha by the switch from a mountain spring to a plains well, which will allow people to introduce mobile tanks.

21. UNPLANNED EFFECTS

The creation of new water points and the improvement of existing ones in every case has had the effect of altering the water resource base of the local area and has thus led to a struggle over the control of the new resource.

The most obvious kind of competition is between the use of the water for domestic uses (including potable water) and its use for irrigation. People in Central Tunisia are very concerned about finding water for irrigation, as irrigation is the major way in which a household envisages improving its livelihood. Consequently, the creation of a water point with additional water resources automatically leads people to think of irrigation uses.

The improvement of a water point also can change use patterns. For example, the installation of a motor on an improved well had the effect of attracting people who had not previously used a well when the only method for drawing water was through the dellu, (a donkey and rope) to draw water up from a depth of 65 meters.

Several of the drilled wells (Henchir Ali Majnoun and Skhira El Beida, for instance) have yielded flows of 25-35 liter/second--considerably in excess of needs specified in sub-project documents(0.5 to 5 l/s).(This extra water is also a resource.)

22. LESSONS LEARNED

1. There is a need for high quality social and economic data as a baseline and a control throughout and beyond the life of the project to access the impact of subproject interventions.

2. Even what is apparently a fairly technical project such as this one has political repercussions at the local level, in this case involving rivalry over new or altered resources.

3. To organize community participation requires full-time staff with some degree of background and training for the job.

23. SPECIAL COMMENTS OR REMARKS: RECOMMENDATIONS

1. The evaluation team recommends the creation of water users' associations in conjunction with each new or improved water point. Such associations would both institutionalize participation by local communities in matters of common interest, and help ensure the success of health education programs and maintenance plans. The formation of such water users' associations could be required as a prerequisite to the construction of any publicly funded water-supply intervention.

2. This would appear to be a new task for the CTDA, and therefore it would be appropriate to create new posts for people with sociological expertise.

(a) The CTDA should create one or two posts for sociologists to carry out studies of the rural society in Central Tunisia, and to follow the evolution of that society particularly in terms of the impact of the potable water and other interventions of the Central Tunisia Development Authority.

(b) One of the first tasks of these sociologists will be to organize the water users' associations around the newly created or improved water points.

(c) If this recommendation is accepted in principle, then USAID should consider financing technical assistance in the form of a visit by someone familar with Tunisian sociology and with the Central Tunisia Development Project who would write scopes of work to carry out (a) and (b) above.

3. The water policy for Central Tunisia should cover both domestic (potable) and irrigation water.

The population of Central Tunisia does not always make a hard and fast distinction between potable water and water for other purposes, notably irrigation. There are separate programs (subprojects) within the CTDA for these two areas--one for potable water, and another for the improvement and establishment of irrigation perimeters, including the encouragement of the construction and equipment of shallow wells by private farmers.

The two subprojects should remain in constant contact and should work together to encourage private initiative (i.e., through loans of money and equipment) to maximize the number of water points and the amount of water available for all purposes. NOTE: The new (10/83) Director of the CTDA has reorganized CTDA staff and amalgamated the two offices concerned with irrigation and potable water in order to promote improved coordination.

4. The following recommendations concern the process of siting and drilling wells.

a. A 6-inch air hammer for the TH-60 drilling should be acquired immediately. NOTE: Air hammer ordered 11/83.

b. Reconnaissance pilot bore holes should not exceed 6-inches in diameter.

c. Well casing of 6-inch diameter be used in place of 9 5/8". NOTE: 6" casing has not been available for this subproject.

d. The TH-60 should be thoroughly cleaned and preventive maintenance performed at least every 200 hours if not sooner.

e. Spare parts in sufficient quantities for the drill rig should be kept on hand and be immediately available.

f. Single side band communications equipment should be purchased to facilitate timely communications between the drill crew, the regional drilling supervisor and central headquarters.

g. Either the national hydrogeological service (DRES) should make available all aquifer-performance-test data from subproject wells to CTDA hydrogeologists or consultants should make an independent analysis of the data and the final decision on well development.

NEAR EAST EVALUATION ABSTRACT

PROJECT TITLE(S) AND NUMBER(S)	MISSION/AID/W OFFICE
RURAL POTABLE WATER SUBPROJECT - 664-0312.7	USAID/TUNIS

PROJECT DESCRIPTION

Improve the access of the rural, dispersed population to potable water through the construction of springs, drilling and equipping of drilled wells, and improving and equipping of dug wells in the CTRD area. Provide drilling rig and supporting technical assistance and evaluation services.

AUTHORIZATION DATE AND U.S. LOP FUNDING AMOUNT	PES NUMBER	PES DATE	PES TYPE
7/10/80 $2,190,000	664-84-2	2/84	[XX] Regular [ ] Other (Specify)
ABSTRACT PREPARED BY, DATE	ABSTRACT CLEARED BY, DATE		[ ] Special
Dorothy Young 1/12/84	Program Office 2/2/84		[ ] Terminal

1. Reason for Evaluation.

This was a mid-term evaluation aimed principally at studying the innovative elements of the subproject (beneficiary participation, site selection methodology, maintenance planning and well drilling) and determining what can be done to improve performance under each of these.

2. Project Status as described in PES

The project is doing a "creditable job of expanding the access of the rural population to potable water at a reasonable cost." Of 48 interventions planned, 10 drilled wells and 10 springs were completed by the end of the evaluation and 13 dug wells were under construction. The implementing agency respected the site selection methodology, but the degree of improvement over existing approaches did not match expectations. Beneficiary participation has increased only very modestly. Maintenance plans have been prepared for each site but have not yet been implemented. The project financed drilling rig has drilled 9 wells and stirred a lot of regional and national interest; the evaluators recommended modifying the use of the rig to improve performance. The Health education activities began at subproject sites but have been curtailed for the moment as the MinHealth claims it lacks transportation for its health educators.

3. Key Findings

(a) The creation of a potable water point leads beneficiaries to think of using the water for agriculture (irrigation); therefore, there needs to be closer coordination between irrigation and potable water projects at all stages. (b) The CTDA does not have the staff needed to implement and monitor the more innovative aspects of the subproject. (c) The drilling rig may be more efficiently used by drilling with an air hammer and drilling smaller bore (6") holes.

4. Lessons learned.

1. There is a need for high quality social and economic data as a baseline and a control throughout and beyond the life of the project to aggess the impact of subproject interventions.

2. Even what is apparently a fairly technical project such as this one has political repercussions at the local level, in this case involving rivalry over new or altered resources.

3. To organize participation requires full-time staff with

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INTERIM EVALUATION: RURAL POTABLE WATER SUBPROJECT (664-0312.7)

by

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December 1983

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Contract No. PDC-1406-I-07-1091-00

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INTERIM EVALUATION: RURAL POTABLE WATER SUBPROJECT (664-0312.7)

INTRODUCTION AND BACKGROUND

The relevant document authorizing the Central Tunisia Potable Water project is the Fifth Amendment to the Project Loan and Grant Agreement, dated July 10, 1980. The project has the number 664-0312.7. According to this document (Annex 2e, p. 1), "This subproject is aimed at (1) improving the access to potable water of the rural, predominantly dispersed, population of the project area, including as many of the most disadvantaged as possible; (2) testing and demonstrating under Central Tunisia conditions lower-cost technologies for providing potable water to dispersed population; and (3) encouraging the CTDA to undertake water activities at sites selected through the application of an agreed set of criteria." The document then goes on the spell out the criteria for potable water interventions, and stresses the importance of taking health concerns into consideration.

Access to potable water is to be improved under the project by ameliorating a certain number of existing water points--capping springs, capping and motorizing dug wells--and by creating new drilled and motorized wells in areas where no other source of pure water is conveniently available. (While the Fifth Amendment refers to the placement of hand pumps on both dug and drilled wells, subsequent experiences have caused this idea to be abandoned in favor of generalized motorization. See Phillip W. Potts, "USAID Handpump Program in Tunisia", WASH Field Report No. 100, final draft for review, August 1983.) The drilling of new wells in particular serves as an occasion to demonstrate the use of

lower-cost technologies hithertofore unfamiliar in Tunisia. The elaboration of a Central Tunisia Potable Water Policy reflects the desire to apply a more rational planning methodology to the controlled use of the present and potential water resources of Central Tunisia.

The outputs foreseen by the Loan Agreement included: (1) an increase in the experience of the CTDA in dealing with potable water interventions, including the development of closer working relationships with other Government and private institutions involved in water development; (2) the creation of a specified number of new or improved water points coupled with functioning maintenance and health education plans; (3) "The subproject should demonstrate the technical feasibility and economic benefits of using lower cost technological approaches to water development and in particular the use of small, more mobile drilling rigs which are capable of drilling to shallow-medium depth aquifers which yield 0.5-5 liters/second, adequate to meet the year-round daily needs of the rural, dispersed population and their livestock".

A Potable Water Policy was elaborated by the CTDA in conjunction with technical assistance provided by the University of Wisconsin. This policy is designed to help the CTDA plan potable water interventions that will support the regional development strategy for Central Tunisia. The policy includes several general considerations designed to assist in the identification of possible interventions (continuous supply throughout the year; help those with least access first; ensure MDPH responsibility for health education and sanitation activities; the CTDA as program manager); a detailed analysis of site selection criteria, including distance/access, number of beneficiaries, cost, quantity and quality of

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water, drainage, proximity to other public services, accessibility, and possible damage to archeological and historical sites; finally a detailed site selection methodology was spelled out to take into consideration "extant demographic, topographical and hydrogeological factors". The site selection methodology also specified a role for beneficiaries as participants in the selection process and postulated that the selection of sites might reflect both administrative (governmental) and social (traditional social organizational) configurations so as to avoid rivalry over control of sites.

A mid-term evaluation 18 months after the implementation of the project was also laid out in the Loan Agreement. Accordingly a Scope of Work was issued in March 1983. It called for the services of a social economist and a water engineer/drilling manager to assist the Government of Tunisia and USAID in the evaluation of the Rural Potable Water Subproject implemented by the CTDA. (The same team had the responsibility for evaluating two projects implemented by SONEDE; this is covered in a separate report.)

The Social Economist was asked in the Scope of Work to evaluate the following issues:

(a) The extent to which rural population's access to an adequate supply (as defined by the project) of potable water has been improved as a result of the intervention.

(b) Extent to which beneficiaries were consulted in site selection, type of intervention planned, future site protection and maintenance, and have been involved in health education activity. Evaluator's recommendations for improving beneficiary involvement.

(c) The appropriateness of the design of the civil work and the equipment at the water points.

(d) Extent to which the site selection methodology and the CTRD potable water policy have resulted in cost savings in project implementation. To what extent have less costly techniques been applied and costs reduced as compared with comparable projects implemented by other institutions? What is the cost effectiveness of spring and well development interventions? If effective, the extent to which other institutions are adopting this methodology and policy. What are the constraints to methodology and policy being adopted by national institutions other than CTDA?

(e) Inadequate maintenance of water systems serving dispersed populations is a key problem which this project has tried to get GOT to address. USAID regards the evaluation as another opportunity to present the issue to national and regional GOT institutions and USAID would like the evaluators to recommend for GOT consideration possible new and imaginative approaches to meet maintenance needs.

(f) Identify possible short-term TA or training and develop scopes of work to promote accomplishing items (b) and (e) above.

The Water Engineer/Drilling Manager was asked to evaluate the following questions:

(a) Cost effectiveness of drilling operations under 664-0312.7 using the imported TH-60 rig as compared with (1) other drilling operations in Tunisia by the same drilling institution, (2) other drilling companies in Tunisia, and (3) drilling performance in general in developing countries.

(b) Extent to which the purpose of introducing lower cost drilling technologies is being achieved and/or is a realistic, attainable purpose in Tunisia based on findings in (a) above.

(c) Recommendations for improving the management of the rig to control and reduce downtime.

(d) Cost effectiveness and appropriateness of pumping equipment installed or to be installed at surface and drilled well sites.

(e) Evaluation of the quality and appropriateness of the construction and design and a sampling of each type of intervention and recommendations for changes if appropriate.

(f) Number of families/houses which have hooked up to new or extended piped water systems installed under the (SONEDE) projects.

(g) Cost-effectiveness of project interventions.

The evaluation team was charged, among other tasks, with "detailed reporting on each of the 13 issues identified above with clear recommendations for changes or improvements where applicable."

A partial rephrasing of the questions would be:

(1) Is the drilling technology appropriate?

(2) What are the relative merits of interventions aimed at capping springs, improving duge wells, or drilling new wells?

(3) Is a government program preferable to one that encourages private initiative?

(4) How rational was the site selection process?

(5) How appropriate is the civil engineering design and execution?

(6) Are the health education and maintenance plans designed feasible and operational?

(7) Are the beneficiaries as many (or more) than expected? What is their benefit--saving time, better water, less cost?

(8) Are the different government agencies concerned able to work together effectively?

(9) What plans or political pressures surround the creation of these new resources (especially the excess flow of the drilled wells)?

(10) Have the costs been kept within reason--both overall costs and cost per beneficiary?

(11) Has there been sufficient participation by beneficiaries in site selection, engineering design, and maintenance issues?

(12) What can be suggested to improve maintenance?

(13) Can people pay for water?

ORGANIZATION OF THE REPORT

This report consists of four main parts.

(1) The first part consists of this statement of the background, scope of work, and acknowledgements.

(2) The second part is an effort to fit our observations into the "Project Evaluation Summary" format. Within this format we have attempted to answer the questions laid forth in the preceding section. There are then two main supporting documents.

(3) The first one, Appendix A, analyzes the data generated by the household users' survey.

(4) Appendix B includes the detailed analysis of the site selection, drilling, and water lifting processes. Each of these appendices includes its own conclusions, but the recommendations and the main observations from them have been included in the main body of the report.

(5) Finally, additional appendices outline the work schedule of the evaluation team in Tunisia.

ACKNOWLEDGEMENTS

The team has rarely had such genuine cooperation and interest fror host country agencies and individuals as has been experienced in the present evaluation. It was a great pleasure to have the support and encouragement of M. Rachid Bougatef, the President-Director General of the Office de Developpement de la Tunisie Centrale. Exceptional cooperation has been obtained from M. Moncef Hossein, Director of the CTDA rural potable water subproject in Central Tunisia, and so most immediately responsible for the success of our mission. M. Mosbah Haj, Director of the CTDA irrigation perimeter projects, was also graciously helpful. M. Mohamed Sakri of the Planning Office of the CTDA was also unfailingly helpful. M. Mondher Naji of the Office of the Save the Children/CDF office in Kasserine offered many useful ideas in our conversations with him.

Our work brought us into contact with the Commissariat Regional du Developpement Agricole in Kasserine. We are grateful to M. Ridha Fekih and all of his staff for the time they so willingly spent with us, and for their thoughtful ideas. Concerning drilling and hydrology, we talked with M. Hamdene Rahoui of the Kasserine office of the Direction des Ressources en Eau et en Sol (DRES) and with M. Ahmed Ben Amar of the Regie des Sondages Hydrauliques (RSH). Concerning maintenance activities we talked with M. Hilali Labidi of the Kasserine office of the Genie Rural (GR). The team has also visited with Mr. N. Bousalem and M. Jafar Hadj of the RSH in Tunis. Mr. Zbidi, Director of DRES kindly discussed practices of DRES and its role in the development and management of water

resources in Tunisia. We also learned a good deal from our visit to the office of the Service d'Hygiene in Kasserine, and we are grateful to them for releasing two of their assistants to serve as enumerators in the users' survey.

All individuals interviewed in the process of this evaluation are clearly extremely competent in their field and are dedicating their respective efforts towards serving their people. We are grateful for the unstinting assistance offered by one and all.

We benefitted enormously from the support and friendly cooperation offered by the USAID/Tunis staff with whom we had the good fortune to work: Mr. James Phippard, Director; Ms. Dorothy Young, General Development Officer; Mr. Chadli Zarg El Ayoun, Assistant General Development Officer, Mme. Naziha Ben Soltane, and many others.

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13. SUMMARY

The findings of the evaluation team of the Rural Potable Water Subproject (664-0312.7) may be broadly summarized as follows:

(1) The subproject has so far done a creditable job of expanding the access of the rural population to potable water at a reasonable cost. Its improvements are generally appreciated, and eagerly awaited. Though the populations concerned have some reservations about the changes in springs and dug wells, these technical difficulties can be resolved. The expansion of the system of drilled wells will rapidly increase the number of beneficiaries, especially if the excess water present in some sites can be made available to populations outside the 4-km radius initially foreseen.

(2) Drilled wells, although relatively costly and demanding in terms of post-construction maintenance and operating costs, provide the best way of increasing the access of rural populations to domestic water. Their sites are new and the access is relatively easy, thus facilitating the use of animal-drawn mobile tanks and so increasing the amount of water people can haul home. If there is more water than the nearby population requires, it can be made avilable to other adjacent areas through piping.

(3) Hand dug wells are the least costly method per capita of water supply development. More than ten hand-dug wells may be financed for the cost of a single drilled well. Hand-dug wells are a popular solution to rural water supply and more than 50 loans have been made by the CTDA irrigation project for the construction of dug wells. Loans or credits could be made available to individuals or rural water users' associations for construction of dug wells.

Only springs and dug wells should be supported if low cost technologies are sought. As a last resort drilled wells may be used. This is because of (a) constraints imposed by drilling conditions; (b) rural water collection practices; (c) well construction supplies available in Tunisia; and (d) lack of maintenance suitable to maintain drilled wells.

(4) Drilling costs experienced with the TH-60 are in line with drilling costs elsewhere. However, it is irrelevant to make the comparison when the TH-60 is being used improperly. This rig was never designed to drill 12.25-inch let alone 17-inch diameter holes using rotary or air hammer methods. The chatter created by using large diameter tricone bits is sending tremendous shock into the mast and hydraulic systems causing failure. The TH-60 is designed to drill 6.5-inch holes most effectively. Holes up to 8-inches may be drilled to 200 meters if foam is added. If hard drilling conditions are encountered, the rig is intended to drill with an air hammer and not tricone bits. Uphole air and mud velocities should be 3000 and 150 feet per minute respectively.

(5) The TH-60 performs better than conventional mud-rotary drilling rigs operated in Tunisia. The long time required to drill wells is caused by:

(a) difficult drilling conditions and lack of an air hammer and appropriate bits;

(b) lack of a regular equipment cleaning and preventive maintenance program;

(c) use of the equipment to drill large diameter holes using tricone bits for which the equipment is not designed--this has caused frequent failure of hydraulic lines and other parts, requiring their replacement;

(d) lack of spare parts at drill sites; and

(e) lack of timely communications between drilling superintendents and spare parts shops in Tunis.

(6) The TH-60 should be used to identify dug-well sites and if necessary to construct 6-inch diameter drilled wells when digging conditions become difficult before water is encountered. When operated properly with a 6-inch air hammer, it will be easy for operators to drill 100 meters or more per day.

(7) If water occurs below 80 meters, hand pumps are not useful for extracting water from small-diameter wells. Bailing the water from wells is feasible but it is time consuming and only a few families may be served. Mechanical pumps can be used. These include electrosubmersible pumps if the well is near a power line, line-shaft turbines, or air lift pumping using diesel-powered compressors. However, any mechanical method requiring more maintenance than the people are capable of performing themselves will require government intervention.

(8) Whenever the terrain is flat enough, rural people use 500-litre animal-drawn tanks to haul water home. This increases the demand for water beyond the point where 0.5 litres per second can satisfy the demands of more than about 30 families or 180 individuals. Such a group is smaller than the target group projected in the project paper and other documentation. This suggests that water points with low flows should not be situated where they will tempt the users of mobile tanks.

(9) The Fifth Amendment to the project Loan and Grant Agreement and the contract between the CTDA and the RSH specified the construction of numerous low-yield wells with production rates of from 0.5 to 5 litres per

second. Wells constructed under the project require large bore holes (15 to 17 inches) and have high yields of from 15 to 43 litres per second. Though the extra water is certainly welcome, these wells exceed the provisions of the contract and agreement.

(10) The site-specific maintenance plans and the health education plans have not yet been put into operation, despite the obvious need for them.

(11) There have been delays in supplying the drilled and dug well sites with motors and pumps, and in recruiting and training pump guards for these sites.

(12) There is room for improvement in the coordination between the different services of the Tunisian government.

(13) The competition between irrigation and domestic uses of water creates a political feud that was inadequately foreseen. This conflict will always be present, but as the government of Tunisia creates new water resources in the rural areas, it must also foresee new local social institutions to allocate the use of water and so channel the conflict. The water users' associations we propose could undertake this role, along with responsibilities for maintenance and health education. Such water users' associations also provide an opportunity to involve rural women in responsible positions.

(14) The participation of the beneficiaries is an area that has not been adequately addressed. There has been no development of an understanding of the local social situations where new water points would be created, in part because no one on the CTDA staff had the relevant social

science training. There is now an opportunity to involve local populations in maintenance activities around the new or improved water points, as well as in allocating the new resource.

(15) The CTDA should recruit new staff with sociological expertise to evaluate the new social situations created by their interventions and recommend courses of action. Such new personnel could also help design and establish the water users' associations.

16. In any future project of this kind, the ability and willingness of people to pay for private wells, or through water users' associations to pay and care for public wells, should be taken into consideration. The use of private initiative with government support may provide a more enduring system than government organization alone.

14. EVALUATION METHODOLOGY

The purpose of this evaluation was to measure the progress accomplished in the Central Tunisia Potable Water Project. To this end we followed the suggestions of relevant topics and measures given in the log frame. Our conclusions about the progress accomplished and the nature of the present situation then lead us to make recommendations intended to improve the implementation of the remainder of the project.

In the Project Paper and again in the Loan Agreement the idea was advanced that the mid-term evaluation should not be an isolated event but should form part of a larger evaluation program. In fact, however, the present evaluation stands alone. This is to be regretted, since especially from the social and economic point of view, the present evaluation would have benefited from the existence of an overall data collecting plan that would have facilitated analyses of interventions both before and after. It should also be stressed that help in elaborating such an overall evaluation plan was not included in the scope of work for the present mid-term evaluation.

For the present evaluation, the Institute for Development Anthropology in Binghamton, New York, was asked to provide a two-member team consisting of a social economist and a hydrogeologist/drilling engineer. The team was completed in Tunisia by a representative of the Tunisia government. The team members were:

Dr. Nicholas S. Hopkins, Professor of Anthropology, The American University in Cairo, Egypt (socio-economist and team leader);

M. Mohamed ben Ali Mogadi, Direction du Genie Rural, Tunis (representing the Tunisian government and focusing on civil engineering and management issues).

Dr. William Turner, American Ground Water Consultants, Albuquerque, New Mexico (hydrogeologist and drilling specialist).

The team began its work on September 2, 1983 in Tunis, and concluded the in-country portion of its work on September 26, 1983, with a debriefing at the USAID Mission in Tunis. In the meantime, the team spent approximately two weeks in Central Tunisia visiting sites, interviewing Tunisian government officials and beneficiaries, and discussing its observations. A joint oral report was made at the offices of the CTDA on September 24, 1983, in the presence of Mr. Rachid Bougatef, President-Directeur General of the Central Tunisian Development Authority (Office du Developpement de la Tunisie Centrale), of Mr. Ridha Fekih, Commissaire Regionale du Developpement Agricole in Kasserine, together with various members of their respective staffs. Also present were representatives of the USAID Mission General Development Office and of the Service d'Hygiene et de l'Education Sanitaire in Kasserine.

Although the potable water subproject covers areas not only in the Governorate of Kasserine, but also in the Governorates of Sid Bou Zid and of Siliana, we concentrated our efforts on Kasserine. This reflected a decision to focus our limited time on the governorate in which there were the most accomplishments to date. However, we did visit a few sites in the other two governorates.

The principal methods used by the team included: (1) interviews with key officials in the Potable Water subproject, both in the Central Tunisia Development Authority and in other branches of the Tunisian government

in Kasserine.. The list of responsible parties contacted is included in the individual work schedules; (2) the study and analysis of previous reports and official project documents. Some of these were supplied by the USAID mission in Tunis while others were provided by the CTDA office in Kasserine; (3) site visits to a representative sample of new water points created or in the process of creation, improved or in the process of improvement. Insofar as the observations from these visits and contacts relate to drilling and hydrology, they are reported in Appendix B; (4) a Users' Survey carried out by a team of Tunisian interviewers in five sites to determine attitudes and practices of the population with regard to the collection and use of potable water. The methodology and results of this survey are described in Appendix A.

15. EXTERNAL FACTORS

There appear to be no major changes in project setting that need to be taken into account at the moment. The project assumptions appear to have given insufficient attention to the potential conflict that could arise once the new water resources were created; this will be discussed further under Item 21, "Unplanned Effects".

16. INPUTS

The project has been consistently running behind schedule, and it is now imperative that all those concerned buckle down to work as hard and fast as possible to get the job completed in the shortest time possible. The project is currently scheduled for completion in early 1984, but it will almost certainly have to be extended beyond that date. The reasons for the delays are numerous.

(1) Problems with the drilling. Though the TH-60 performs better than conventional mud-rotary drilling rigs operated in Tunisia, the long time required to drill wells is caused by:

(a) lack of familiarity with the drilling rig;

(b) difficult drilling conditions and lack of an air hammer and appropriate bits;

(c) lack of a regular equipment cleaning and preventive maintenance program;

(d) use of the equipment to drill large diameter holes using tricone bits--since the equipment was never intended for this, it has caused frequent failure of hydraulic lines and other parts thus requiring their replacement;

(e) lack of spare parts at drill site; and

(f) lack of timely communications between drilling superintendents and spare parts shop in Tunis.

(2) Earlier in the program there were delays in choosing the sites for the interventions. To some extent these delays reflected difficulties in following the Potable Water Policy for Central Tunisia elaborated with

the assistance of the University of Wisconsin. Since no new sites are likely to be chosen under this subproject, the detailed reasons for this slowness were not evaluated.

(3) Problems with the contractors for the civil works. Here perhaps one part of the problem is the relative inexperience of the contractors. In an area like Central Tunisia there are few private individuals willing to take on the kind of work that this project involves--relatively small-scale tasks frequently located in relatively inaccessible parts of the country. The CTDA sees the encouragement of such small-scale contractors as part of its mission. In the meantime, however, there are errors in construction that are committed and have to be corrected. Whether under these circumstances the contractors can manage to make money is worth considering. In one case, the design called for taps on the reservoir. Since these were initially forgotten, they had to be installed by breaking the cement wall of the reservoir with a consequent weakening of that wall and increased danger of leaks. In another case, the contractor allowed himself to be persuaded to make a change of design by a delegue who was in turn reflecting the expressed desires of the population. Since this change in design resulted in a nonconformity with the original standards concerning pure water, the contractor had to rectify the matter; but, the end result probably fully satisfied no one--not the contractor, not the community, and not the CTDA.

Most of the bidding takes place between the same two or three contractors. The CTDA pretty consistently accepts the lowest bid that appears to be responsive, although it may be true that in some cases the foreseeable costs exceed the bid. The result of a bid that is unrealistically low is a tendency to cut corners, and perhaps ultimately a delay.

(4) There are many causes for delay built into the motorized sites. The motor cannot be ordered until the technical specifications of the site are known, and then there are frequent delays in getting the right motor in place on the site. While the causes for these delays were not investigated by the evaluation committee, it would seem an area where some improvement is possible and desirable.

(5) There have been delays in identifying the pump operators and in training them. These individuals are key to the whole operation, and it is essential that their relatively low status on the national scale not blind people to the need to recruit good people, train them to be better, and keep them on the job.

(6) There has been a delay in developing the site-specific maintenance plans. This has caused a delay in reimbursing the CTDA for the costs of the interventions, but it has also meant that many completed sites are currently in limbo. They are not yet the responsibiilty of the Genie Rural, and the CTDA is itself not equipped to provide the necessary maintenance. The site-specific plans were in the process of being signed when the evaluation team was in Kasserine, and it is to be hoped that they will quickly be acted upon. In the future there should not be such a delay.

Since these plans have never been put into effect, it is impossible to comment on their operation. The Governor of Kasserine was reported to have assured all concerned that there would be no problem of funds, despite the fact that the national budget for maintenance is chronically inadequate. The Governor's comment was reassuring. But the fact remains that the infrastructure for maintenance is not in place. The GR complains

that it has neither an adequate staff nor adequate transportation, and without these even the easiest access to the budget of the "Conseil du Gouvernorat" will not solve the problem. In general, the committee was not convinced that the maintenance plans will materialize fully and feels that this is an area that still needs a great deal of attention. More than a budgetary question, it also involves suitable technicians, transport, and appropriate training for pump operators/guards. A maintenance problem cannot fairly be blamed on an operator who has been assigned without adequate training.

The representatives of the GR in Kasserine also raised another problem with the evaluation committee. Since they feel themselves responsible for maintenance of all the water points in their governorate, they were apprehensive about being bound by an agreement that they felt required them to give priority attention to some of these points (the CTDA sites) only. One might argue that what they can do for the CTDA sites they can do for the others, but in the meantime perhaps they need some reassurance.

(7) Although a general plan for health education and sanitation was developed fairly early in the history of the project, it seems to have remained a dead letter. The Kasserine office for Health Education attributed this to their lack of vehicles to move their personnel to the countryside. The CTDA should work together with the Service d'Hygiene to resolve this problem and to allow the sanitation education workers to reach the areas surrounding the new or improved water points. Because there was no on-going health education, the evaluation committee was unable to judge the content of the advice or instruction offered. However, it should be clear that effective advice has to start from the

actual situation that people find themselves in, and from their present habits. .These are not always the same throughout the area. Advice which does not make sense to the people can do more harm than good.

(8) The problem of the participation of the population has not been sufficiently tackled. Although there was some consultation with local political representatives at the time of site selection, there appears to have been little since. Furthermore, the local political representatives appear to have been consulted mostly in order to select the "sectors" which the subproject would try to help, not to locate the drilling site within the sector, and much less to help in maintenance and health education programs. In the conclusion to this evaluation report we will make some recommendations concerning expansion of the participatory role of the population.

(9) The Potable Water Intervention Approval Committee has rarely met, and recently not at all. The CTDA seeks their approval by circulation rather than through a meeting. It is not clear whether this is a specifically Tunisian way of doing business or an effort to avoid confrontation and argument. In the meantime the Ministry of Public Health is resentful at having been left off the committee. While this is not specifically a cause for delay in the program, especially now that all the sites have been chosen, it does reflect a more general problem in getting representatives of different government offices to work together effectively. This problem is not specific to Tunisia.

The reasons for the delays are numerous, and it was not possible in this evaluation to sort out the relative importance of each. Some of them affected stages in the process that are now completed; others are still relevant.

17. OUTPUTS

(1) The revised goals aimed at the construction of 18 springs, 14 shallow wells, and 16 drilled wells, for a total of 48 interventions. At the time of the evaluation, relatively few of these were completely done. Drilling of new wells and the implementation of civil works to improve spring and surface wells were begun in the summer of 1982. Of the 48 separate physical interventions planned under the subproject, five springs and five drilled wells were completed as of March 1983. The remaining interventions then included 13 springs, all 14 motorized surface wells, the drilling of eleven wells and civil works for all 16 drilled wells.

Not much additional progress was recorded between March and September 1983. The only shallow well to be completed was Bir Guerguera, and there were some start-up problems there. The only drilled well to be completed was Henchir Ali Majnoun, and again there were problems there getting the motor to work properly. Approximately seven of the springs were completed.

To express the matter this way is to neglect the fact that many interventions were largely done. Several more shallow wells were ready for motor installation, but the motors had not yet been delivered. The same was true of some of the drilled wells. In other cases, the contractor had not quite finished working on the civil constructions. It is likely that the number of completed interventions will grow rapidly in the coming months, particularly if the problem of supply of the motors can be solved. Most of the springs and shallow well interventions are scheduled for reimbursement by the end of 1983.

(2) To introduce a new technology for drilling relatively shallow wells suitable for the small numbers of a dispersed population, a medium-sized drilling rig (the Ingersoll-Rand TH-60) and six months technical assistance by two different drilling specialists were grant-financed under the subproject. The rig was put into operation in June 1982, and has since drilled several wells, including some "dry" holes. This rig is operated by the Regie des Sondages Hydrauliques, a government outfit under the Ministry of Agriculture. By the sumemr of 1983, the RSH was supplementing the TH-60 by an older rig in its possession, the Franks 2000.

(3) Other project outputs are health education activities and maintenance plans for each site. This subproject also aims to introduce a new systematic approach to site selection, to promote the adoption of lower cost technologies, and to promote coordination among the various institutions involved in water and sanitation services.

It would have to be said that the efforts to introduce a more systematic approach to site selection, and to promote coordination among the various institutions involved in water and sanitation services, have been only very partially successful.

The staff at the CTDA are aware of the difference between their approach to site selection and that followed by (say) the Genie Rural. They argue that in contrast to the GR's tendency to react to pressing demands made by rural populations through their political leadership, the CTDA actively seeks out areas and sectors that are in need of water. They did this by identifying sectors where there was a demonstrable need for potable water. Then a choice had to be made whether to improve an

existing water point or drill a new well. It appears that the CTDA staff did not influence the choice of the site of a new drilled well within the sector. This choice was made by the Direction des Ressources en Eau et en Sol (DRES) according to hydrogeological criteria. For this reason, some of the drilled wells appear to be poorly situated vis à vis the actual population concentrations and the accessibility of alternative water points in the area. Although the loan agreement called for the creation of a set of three maps, it is not clear that these were ever used in the manner intended. For one thing, the map of hydrogeological resources was kept by the DRES and hence separately from the other two. Moreover, the demographic information was hard to come by in any detail. The best available maps in Tunisia do not always use the same place names as those used to identify localities in the census of 1975 (the latest census); thus it was hard to plot this census information on a map. The CTDA possesses a set of aerial photographs, but it does not seem that they were systematically used in site selection. Thus the method followed represents something of an innovation, and respects at least the broad outlines of the water policy elaborated with the help of the University of Wisconsin, but the degree of change does not match that expected.

Moreover, the relations between the CTDA and the other Tunisian institutions, while they appear superficially cordial, are clearly not close, and it is uncertain how much coordination there is. As evaluators it is hard to make a statement comparing past and present. We have already cited the difficulties in getting the health education and the maintenance programs started.

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In general, one might say that the emphasis has been on completing the physical interventions. Concern with managerial aspects and any new patterns of social relations has been secondary and somewhat neglected. The same is true of participation by the beneficiaries in the program. This selective concentration is due partly to natural predelictions on the part of the program staff, and partly to the sheer amount of work involved in completing the physical interventions. Given the lack of specialized training in managerial or community development-type work and the press of work in supervising the construction phase, it is not surprising that some of these other concerns have been neglected.

(4) The team recognizes that the plans and the civil constructions themselves have been approved by USAID, and are thus in accord with the loan agreement. However, M. Mogadi made the following notes for future reference:

(a) The shelter for the motor should provide room enough for the guardian and the stock of fuel as well as for the motor.

(b) The reservoir (tank) should be raised (not sitting on the ground as at present) and large enough to supply the standpipe used to fill mobile tanks.

(c) The standpipe should be connected to the reservoir and not directly to the pump.

(d) No taps should be placed directly on the reservoir; but additional taps should be placed at the adjacent public tap.

(e) The reservoir should be insulated from the heat.

(f) The entire area of the water point should be enclosed with a fence, allowing perhaps one fairly wide entry point.

(g) A drain should be placed near the reservoir to absorb waste water.

Participation - Increased participation of populations in decisions concerning their own fate was intended to be one of the outputs of the subproject. We have noted many instances of political pressure connected with this project. This political pressure is brought to bear by a group of people in the countryside who develop a collective demand. They then go to see their delegue, who is likely to take their demand very seriously and try to find a way to satisfy it. He is prone to do this because he knows that he will be judged by the population according to his ability to "produce" for them. Thus although he is an official appointed from outside the area, he often behaves more like an elected on. The end result of this pressure may be, however, a substantial modification in the original plan (as in the Um Fadgha and Ain Mellah cases discussed below). This is a form of participation, one that fits in well with the general Tunisian political system with its emphasis on a people that "asks" and a government that "awards". It is not the kind that the authors of the project paper and subsequent documents had in mind.

The first problem in organizing or eliciting participation is that of determining the group that is involved. This can be complicated in the case of Central Tunisia because there are no "villages" or other visible communities on the ground. One is tempted therefore to think that such communities do not exist. However, one form of "natural community" does exist--the 'arsh or "tribe". Community development efforts at the end of the colonial period attempted to use this structure for development purposes (see A. Bessis et al., Le Territoire des Ouled

Sidi Ali ben Aoun: Contribution a l'etude des problemes humain dans la steppe tunisien, Publications de l'Institut des Hautes Etudes de Tunis, Memoires du Centre d'Etudes de Sciences Humaines, #1. Paris, 1956). Since independence the Tunisian government has preferred to work with more arbitrarily defined boundaries between governorates, delegations, and sectors or 'imada s. Nonetheless the "tribal" structure remains in place, and is a potential social resource if one chose to activate it.

However, another alternative is to create special interest groups around well-defined resources. Hence the notion of Water Users' Associations that can reflect the new water points, or, indeed, new or old irrigation perimeters. Here participation would have to await the emergence by a new formal organizataion. One would hope for a set of concerns that would bring the largest possible number of people into the process of participation, specifically including both men and women.

18. PURPOSE

The project purposes are given as three: (1) to improve the access of the dispersed poor in the CTRD project area to potable water; (2) to encourage the CTDA to apply a rational policy for siting, designing and maintaining rural potable water systems; and (3) to test and demonstrate in Central Tunisia lower-cost technologies for providing potable water to dispersed populations.

The first purpose seems sure to be achieved, though the numbers affected may have to be calculated differently than in the project provisions--i.e., on the average fewer sites but more people in the catchment area of each one. The initial documentation was based on a figure of 160 water points to benefit an average of 500 people or a total of 80,000 people; this number was revised downwards fairly early because of a gross underestimation of the costs involved particularly in drilling wells so that the actual project implementation concerns 48 water points. Using the same average figure for the beneficiaries the total population concerned would be 24,000; but it is likely that the average is at least twice as much.

The second purpose has been very partially achieved. A "more rational" policy was followed in the site selection here, but there is no way to be sure that it will ever be followed again. The problem is less with the philosophy behind the policy and more with the practical difficulties with implementing it--getting adequate data, having sociologically aware people with a field orientation to inspect and analyze the sites ahead of time, making sure that socio-economic factors weigh at least as heavily as technical ones in site selection, etc.

The lower-cost technologies have been demonstrated to some extent in Central Tunisia. In particular, the Ingersoll-Rand TH-60 drilling rig has attracted a lot of attention. It should be noted, however, that we are talking about lower-cost technologies available to institutions such as the Government of Tunisia, not those small enough in scale to be usable by the population at large.

19. GOAL/SUBGOAL

The project goal is given as "Improved quality of life in the CTRD program area". Two indexes of this are given: (1) to bring the morbidity rate down to the present national average, and (2) to reduce the time required by women and children to haul water for domestic uses. The effects of the project are still on a small enough scale to preclude the use of morbidity figures drawn from official sources. The results of the users' survey given in Appendix A provide some information on both points. On morbidity they are probably not to be taken too seriously since they rely on individuals' self-diagnosis, and they were collected at a relatively unhealthy time of year (end of the dry summer season). They are somewhat more reliable on time. Here we see that the real time-savers will be those living near the newly created water points, followed by those living in the catchment areas of improved dug wells. However, in these cases those who fetch water are usually not the women but the men and boys. Women and girls are more likely to fetch water when the water point is a spring; here perhaps the saving in time is less important that other factors such as cleaner water.

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20. BENEFICIARIES

For detailed information on the beneficiaries, see Appendix A.

The clearest beneficiaries are those living within a four-kilometer radius of the new drilled wells. In many cases, the entry into operation of these wells will permit people to shorten the distance they must travel for water considerably. This effect will be enhanced in the case of a site like Um Fadgha by the switch from a mountain spring to a plains well, which will allow people to introduce mobile tanks.

In the case of the improved wells and the springs, the benefits are somewhat mitigated. In the case of Bir Guerguera, the improvement of the well has attracted many new users, so that the number of people who benefit has increased but at the same time the sense of overcrowding has been sharpened. The increased amount of water available may also encourage the spread of mobile tanks. At Ain Smiria the number of users has not increased. While people recognize that water quality has improved, there is a lingering feeling that the quantity has been reduced. At Ain Hajrat Ettir, the improvement of the spring allowed it to be switched from animal use to domestic use, at least until the flow dried up in summer and the tap was broken. At both springs, there is a complicated pattern of water use, with people getting water from different places for different purposes at different seasons.

It may be that the best strategy is to concentrate on augmenting the number of new drilled wells in areas far from existing water points. This increases the total amount of water available for domestic (and other) uses, and reduces the effort needed to haul water home for the affected segments of the population. The same effect could be achieved by pumping

excess water from one such drilled well to another point centrally located with reference to population, provided the geography lends itself to this. Some additional springs and wells could be improved, but as the number of these is finite and the most logical cases have already been done, it will increasingly be difficult to find suitable cases for intervention. The attractiveness of such interventions is that the cost is a good deal less, both absolutely and in per capita terms.

21. UNPLANNED EFFECTS

The principal unplanned effect appears to be an underestimation of the level of conflict and competition that the new resources would arouse. The creation of new water points and the improvement of existing ones in every case has had the effect of altering the resource base of the local area and has thus led to a struggle over the control of the new resource.

The most obvious kind of competition is between the use of the water for domestic uses (including potable water) and its use for irrigation. People in Central Tunisia are very concerned about locating water to use for irrigation; this appears as the major way in which a household envisages helping itself on the spot (see Nicholas S. Hopkins, "Elements for a social soundness analysis of the agricultural interventions", Central Tunisia, USAID, Tunis 1978). Consequently, the creation of a water point with additional water resources automatically leads people to think of irrigation.

We found this pattern in the case of the Um Fadgha drilled well, where the estimates of the flow are 3 l/s. When we asked people what they thought they would do once the well was functioning, all of those fairly near the well answered that they hoped to get enough water to irrigate a small garden. However, this use of water was not the only one foreseen by the people nearest the water point. One man in this area talked of buying a tank to go with the tractor he already had, claiming that this would allow him to haul and sell water to people living at some distance from the water point. Since this water point was not yet in operation, it may be that people did not fully realize the implications of the small flow. The contrast between reality and their plans may prove

all the more disappointing. It was also at Um Fadgha that some members of the potential user group objected to placing the reservoir and the faucets near the drilled well itself, arguing that it was too far from the people to be served. As a result, a two-km pipeline (the maximum under the loan agreement) was under construction leading to a reservoir and related construction. We were told that those people a little further along are still dissatisfied with this arrangement: it may lead to a proprietary interest in the part of the small group around the reservoir.

The pattern also occurred in the case of the improved spring site of Ain Smiria. Here a gardener had tried to dig a channel to guide the excess water from the animal trough to a nearby orchard; in fact there seemed to be some feeling that he had used this water before (impossible for us to verify) and that he needed to continue getting it if his orchard was to survive. Since his channel was not working very well, the result was a lot of stagnant water and mud around the animal trough.

In the case of the improved spring site of Ain Mellah (near Rohia), the inhabitants, who had been in the habit of using this water to irrigate a few orchards and vegetables, persuaded the contractor and the delegue to build an open tank from which they could irrigate as part of the new installations. The problem is that the contractor misunderstood the principles involved, and so he built the tank between the spring and the potable water outlet. The result would have been polluted water at the tap if this system had been allowed to function. The CTDA obliged the contractor to construct a pipeline connecting the potable water outlet to the pipe from the spring above the irrigation tank, thus

making sure the water was pure but perhaps with diminished flow. The trade-off for the people living in this area was that they got or would get potable water closer to home, but perhaps at some cost to their supply of irrigation water. The creation of this new resource--potable water--also meant that people from neighboring hamlets might be tempted to come in, whereas when the water could only be used for irrigation and for watering animals, there was less to attract neighbors.

Something of the same kind of thing happened at Ain Hajret Ettir. Here also a spring that had only been used to water animals (it was unclear to us whether it was also used for irrigation, but if so it must have been on a tiny scale) could now be used for potable water. This set up a new pattern of use, attracting new people to the spring in search of potable water. Since we heard stories that the locally powerful individual, who lived near the spring and whose land surrounded it, tried to prevent this new use after a while, it may be that the new patterns disturbed some people. At any rate, we found the faucet had been broken (because of the low flow in the summer, the project had built a tank to store the night flow, and water only flowed out of this tank when the faucet was open). It is tempting to link this breakage to the dispute over the use of the new resource of potable water.

The spring cases illustrate the point that improvement of a water point can change the use patterns. The same thing has happened in the Bir Guerguera case, where the installation of a motor on an improved well has had the effect of attracting people who did not use the well when the only method for drawing water from the well was through the dellu, the use of a donkey to draw water up from a depth of 65 meters or so.

There is thus some degree of conflict between the "traditional" users of the well and the newcomers. In this case, the conflict may be attenuated when other nearby wells are equipped under the potable water subproject and begin to function. However, it often appears to be the case that an improved water point will attract new users from outside the intended zone.

The Ras el Oued drilled well appeared at the beginning to have a high flow. Since it was near the city of Makthar, which has a chronic water shortage, the local citizenry determined to acquire this water for the urban system. There was considerable local political pressure brought to bear on the project and on the SONEDE to do this. SONEDE's reluctance was due to their estimate that the high flow would not last, an estimate that proved correct. Nevertheless, temporary pipes were laid down to bring the water to Makthar. At the moment the flow appears to have declined to around 3 l/s; no engine has been installed and so not even that much water is being pumped.

Several of the drilled wells (Henchir Ali Majnoun and Skhira el Beida, for instance) have yielded flows of 25-35 l/s. This is considerably more than the amount specified in the project documents--from 0.5 to 5 l/s. This extra water is also a resource. In the case of Skhira el Beida, plans are underway (not under the current project) to pipe some of this water to provide drinking and domestic water for the community of Ramada, which has been chosen as the seat of the new delegation of El Aioun. It nevertheless appears that some water may remain even after the local population and that of Ramada have been satisfied. Here we refer to the official Tunisian priorities for water, as expressed by M. Fekih, the Regional Agricultural Commissioner: first water for

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drinking and domestic use, then water for irrigation, with people near the water point having some preference over those further away. According to this logic, once the local people and those of Ramada have been supplied with drinking water, then the remainder can be used for irrigation. The problem then arises of deciding whether this should be a government sponsored and organized irrigation perimeter, or whether the water should be made available to local people (but which?) for them to use for irrigation.

The same kinds of issues have not yet arisen in the case of Henchir Ali Majnoun, but one would have the right to expect some version of them. The point is, in all these cases, that there is some degree of political conflict--between local people favoring different uses of the water, between different branches of the government, and perhaps between the bureaucratic logic and the people's plans for the use of the water. This conflict is not an accidental outcome of one or two cases; it is a predictable outcome of all cases. And yet there is no machinery to handle this outcome. To that extent, the creation of new resources--whether improving undrinkable water to potable water, or creating totally new water points--is going to stimulate competition for the control of these resources; that is an "unplanned effect". The project paper, for instance, foresees as the only effect on the ground of the project that more people will have access to better quality drinking water. That was certainly an effect, but it was not the only one.

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22. LESSONS LEARNED

(1) The need for high quality social and economic data as a baseline and a control throughout and beyond the life of the project.

(2) Even what is apparently a fairly technical project such as this one has political repercussions at the local level, in this case involving rivalry over new or altered resources.

(3) To organize participation requires full-time people with some degree of background and training for the job.

23. SPECIAL COMMENTS OR REMARKS: RECOMMENDATIONS

(A) The evaluation team recommends the creation of water users' associations in conjunction with each new or improved water point. Such associations would both institutionalize participation by local communities in matters of common interest, and help ensure the success of health education programs and maintenance plans. The formation of such water users' associations could be required as a prerequisite to the construction of any publicly funded water-supply interventions.

The Water Users' Associations will have responsibilty for administering all questions relating to the new resource. They could take over responsibility for local maintenance--i.e., maintaining the cleanliness and the sanitation of the area around the water point, ensuring that water points without a guard do not suffer damage, etc. They could help organize local financial contributions to upkeep and construction. They could take on some responsiblity for settling disputes that might arise because of the allocation of the new resource. This would involve allocation of water between domestic and agricultural uses, conflicts between those who want to run the water into large tanks for sale to distant users and those who want to retain free access for local individuals, conflicts arising from the watering of animals, or conflicts breaking out when there are too many people waiting for water. This same association could speak on behalf of the local population to the government on a number of issues, but including the advisability of creating an irrigated perimeter.

These Water Users' Associations would have to work closely with the existing political system, notably the shaykh, the delegue, the party cell, and so on. Since there would be a certain tendency for them to fall under the influence of a few locally powerful individuals, someone would have to remain vigilant to ensure that no exploitation occurred.

It may be possible to utilize existing Tunisian legislation concerning the "Associations d'Interet Collectif", which have been successful in the Gabes oasis in controlling water use and making collective decisions concerning water. (See Abid Bechraoui, La vie rurale dans les oasis de Gabès (Tunisie), Tunis, Publications de l'Université de Tunis, 1980, p. 82.) Act No. 63-18 of 1963 in which Article 22 provides that landowners in public irrigation zones may be compelled by decision of the Secretary of State for Agriculture to join agricultural water groups. This same authority should probably be extended to rural water supply projects in Tunisia.

In an irrigation project, the beneficiaries are clear. However, in the case of potable water, a major difficulty will be to determine who the users of a certain water point are--since some people use the water point forcertain purposes but not all, others use it seasonally, and others sporadically. In some cases one might be able to rely on the local "tribal" structure to determine the boundaries of the group.

The creation of these Water Users' Associations and the designation of individuals from the government side to work with them would require a good knowledge of the local social structure, and the ability to follow up their activities. The Associations ought to be left to govern themselves as much as possible. But some kind of continued government contact

is necessary. This would amount to community development--working with the Water Users' Associations to ensure that decisions concerning the use of water are properly (democratically) taken would naturally lead to a concern with local and rural development per se.

(B) This would appear to be a new task for the CTDA, and therefore it would be appropriate to create new posts for people with sociological expertise.

(1) The CTDA should create one or two posts for sociologists to carry out studies of the rural society in Central Tunisia, and to follow the evolution of that society particularly in terms of the impact of the potable water and other interventions of the Central Tunisia Development Authority. At the moment the CTDA has no capacity of this kind, and yet some parts of the loan agreement clearly call for a sociologically-informed view of local society. It is not fair to expect the engineers who are supervising the construction of the water points also to have the skills necessary for this work. We would prefer to recommend two sociologists rather than one because the role of sociology in the CTDA will have to be defined, and it seems more effective to have two people to work together who can share their experiences. One of the two could be a woman, which would help introduce this badly needed viewpoint into the deliberations of the CTDA.

(2) One of the first tasks of these sociologists will be to organize the Water Users' Associations around the newly created or improved water points. As this work progresses, it may prove necessary to expand the number of people involved, by adding some young sociology graduates to the team. These graduates would work under the supervision

of the senior sociologists and each would have the task of working in detail with a limited number of Water Users' Associations, to assist them in making decisions concerning the local use of water.

From a conversation with Dr. Lilia Ben Salem of the Department of Sociology at the University of Tunis, I believe that these people could be recruited from recent or not-so-recent graduates of that department, including some with post-graduate training. Dr. Ben Salem suggested to me that it might even be possible to recruit people from the region, and cited the case of a sociologist from Gafsa, now working as a French teacher, who might be an appropriate person.

(3) If this recommendation is accepted in principle, then USAID should consider financing technical assistance in the form of a visit by someone familiar with Tunisian sociology and with the Central Tunisia Development Project who would write scopes of work for these tasks. This assignment would involve working, on the one hand, with the members of the department of sociology at the University of Tunis and with the sociologists and geographers of the Centre d'Etudes et de Recherches Economiques et Sociales (CERES), the major research organization attached to the University of Tunis, and, on the other hand, with the relevant offices at the CTDA, such as the Evaluation and Planning Unit and those responsible for the potable water subproject. The purpose of the visit would be (a) to determine the feasibility of creating such posts within the CTDA; (b) to define the scope of work of the different posts, in effect designing a program of technical sociological support for the new communities created by the potable water interventions; and (c) to ensure that recruitment from these posts would not be a problem by establishing

proper links between the CTDA and the academic sociologists (teachers in Tunis can function as an informal job referral agency just as much as in the U.S.). This job would probably take around two weeks, or ten to fifteen working days. It would involve a field trip to Kasserine, preferably in the company of one of the senior sociologists from the University of Tunis, and additional work in Tunis. (This paragraph can be considered a scope of work for this technical assistance.)

(C) The water policy for Central Tunisia should cover both domestic (potable) and irrigation water. We have observed throughout this report that the population of Central Tunisia does not always make a hard and fast distinction between potable water and water for other purposes, notably irrigation. The distinction between these two "kinds" of water exists at the bureaucratic level in that there are separate programs (subprojects) within the CTDA for these two areas--one for potable water, and another for the improvement and establishment of irrigation perimeters, including the encouragement of the construction and equipment of shallow wells by private farmers. The recent evaluation of the "Dryland farming systems research subproject" and the "Small holder irrigation development subproject" (USAID/Tunis, April, 1983), and especially the "Isely report" appended to it, has shown that water developed for irrigation is frequently used for domestic purposes as well. In this evaluation we have several times reported that people use water developed for irrigation for domestic uses. Thus USAID and the CTDA should not let the bureaucratic distinction between these two subprojects blind them to the fact that any particular source of water is often used for both purposes.

We have also noted that people are quick to see the irrigation potential of water intended for domestic use. It is appropriate that excess water should be used for agricultural purposes, although it should be recognized that a decision will have to be made whether to encourage private exploitation of such water, or to expect the government to create an irrigated perimeter.

A further implication of this is that one way to improve the availability of potable water to the dispersed poor rural populations is to encourage them to use their private initiative to construct shallow wells. From this point of view it does not matter whether irrigation or domestic use is the top priority, for the water will be used for both purposes if there is enough of it.

Thus the two subprojects should remain in constant contact and should work together to encourage private initiative (i.e., through loans of money and equipment) to maximize the number of water points and the amount of water available for all purposes. It also follows that the health eduction component of the project should focus on the privately dug shallow wells as well. This would be a reason for the health education to aim at individual households rather than simply those who cluster around a given water point, because the lessons taught and learned will apply to all water points. The privately owned wells have the advantage that their maintenance is not a government responsibility. However, the responsible government body, in this case, DRES, has to continue to approve the construction of such wells to avoid problems due to a falling water table.

(D) The following recommendations concern the process of siting and drilling wells. We recommend the following actions be implemented:

(1) A 6-inch air hammer for the TH-60 should be acquired immediately, as originally recommended by Maupin. Operating at 17 bar, penetration rates of up to 30 meters per hour may be obtainable in the hardest rock likely to be found in Tunisia. The air hammer and two bits should cost about $10,000. In addition, it will be necessary to purchase a button grinder and gauge to reshape buttons on the air hammer bits.

(2) Reconnaissance pilot bore holes should not exceed 6-inches in diameter. Using an air hammer, collars will not be necessary and adequate data can be obtained from the pilot hole to determine well yield and screen placement. This data will include in the following order: (1) bailer or injection tests to determine well yield and pump selection; (2) an electrical conductivity meter should be used for on-site determination of water quality; (3) electric logs to determine placement of screen; (4) sample analysis to determine size of screen slots. If the well when tested is determined to be unproductive it should be abandoned as far as the project is concerned.

(3) Well casing of 6-inch diameter be set. In general, low-yield wells will not require gravel packing or high horsepower pumps. Also, PVC casing may be acceptable.

(4) The TH-60 should be thoroughly cleaned and preventive maintenance performed at least every 200 hours if not more frequently.

(5) Spare parts in sufficient quantities should be kept on hand and be immediately available.

(6) Single side band communications equipment should be purchased to facilitate timely communications.

(7) All aquifer-performance-test data from wells should be made available to CTDA hydrologists or consultants for independent analysis of data and final decision should rest with CTDA just as SONEDE reserves final decisions. Under the project, 0.5 litres per second is acceptable.

(8) BIRH numbers should be granted immediately upon application and upon presentation of a map showing the well location.

(9) The TH-60 should be used for exploratory drilling to identify likely sites for dug wells if dug wells are to be funded by the program.

(10) For such low yield wells,it should not be necessary for DRES to carry out detailed hydrogeological siting studies. The study is likely to cost more and take longer than the well itself.

(11) Well-siting studies should be conducted to define the density of population around potential sites of drilled wells. Other factors may also be considered in locating wells. These studies can be justified if the time and cost of drilling is high.

(12) The concept of numerous low yield wells with mechanical pumps dotting the countryside should be abandoned as impractical if the burden of the cost is on the government. If local people organize such services for themselves it is another story, and government can assist.

(13) In areas where small capacity dug wells and drilled wells are not feasible, larger capacity wells should be constructed. This larger amount of water can then be distributed over an area of up to 600 square kilometers or more. However, the TH-60 will not be capable of drilling such large wells.

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WORK SCHEDULE

A. Dr. Nicholas S. Hopkins

9/ 1/83 Th Travel from Cairo to Tunis, begin reading documentation.

9/ 2/83 Fri Work at USAID Mission in Tunis. Meet with Dorothy Young, General Development Officer, with Mission Director Mr. James Phippard, with Mr. Mohamed Ali Hassairi (responsible for SONEDE projects), etc. Continue reading project documentation.

9/ 3/83 Sat Meet with Young, USAID Regional Engineer Tibor Nagy, Hassairi, and William Turner. Plan evaluation schedule and pinpoint major concerns.

9/ 4/83 Sun Rest

9/ 5/83 Mon Meeting with M. Abdelazis Marzouk, Director of Studies, SONEDE, and with M. Mohamed Ali Khouadja, Project Director for the USAID SONEDE projects 664.0312.4 and 0318. Scheduled meetings with M. Zbidi (DRES) and M. Mokhtar (SIF) were cancelled.

9/ 6/83 Tues Meeting with M. Sadoq Youssef and M. Ferjani Bakkar of Genie Rural (concerning their role in maintenance and in rural water supply generally). Meeting with M. Sadoq Atallah of the Ministry of Public Health concerning health education and sanitation issues in rural water supply.

9/ 7/83 Wed Departure for Siliana, received by M. Mokhtar Jebri, Chief of New Construction, substituting for M. Mohammed Ben Houidi, on leave. Jabri accompanied us on site visits to El Kantara and Sidi Hamada; we made further visits on our own to Gaafour and El Krib. Meeting with Dr. John Rich and Mijo Rich in Lakhouat concerning health education. Later in Makthar we visited the CTDA drilling site at Ras El Oued.

9/ 8/83 Thur Site visit to Kesra. Meeting with M. Mohieddine Ghezaiel, délegue of Kesra, concerning maintenance issues. Interview with M..Ridha of the Community Development Foundation office in Makthar concerning maintenance on CARE sites. In Rohia, visit to CTDA sites at Hmeima (dug well under construction) and Oued Labiadh (spring capping poorly done), and also to a CTDA irrigation drilling site and to a well-functioning former CARE well site. Visit to SONEDE public taps in Rohia and Jedliane and along the road from Sbiba to Rohia. Visit to CRDA capped spring at Ain Smiria, south of Sbiba, and to Ain Khamisia (drilled well for irrigation but some water taken for domestic use) and to Znadia (Genie Rural improvements on an old Roman well, but work stalled).

9/ 9/83 Fri	Meeting with M. Bhouri, SONEDE/Kasserine. First contacts with the CRDA office, especially with M. Moncef Hussein and M. Mosbah Hajji. Site visits to Draa Retba (Henchir Bgar), both old and new sites, then to Ain Tounzar and to Ain Hajret Ettir (capped springs).
9/10/83 Sat	Preparation of questionnaire for the users' survey with MM. Sakri, Hussein, Hajji, Mme. Bouazizi, et al. Site visits to Henchir Ali Majnoun (drilled well), Bir Guerguera (improved duge well), and Ain Zaouia (capped spring).
9/11/83 Sun	Work on questionnaire at hotel.
9/12/83 Mon	Meeting with M. Taher Missaoui and Dr. Belgacem of the Education Sanitaire Office in Kasserine. Work on questionnaire.
9/13/83 Tue	Meeting with M. Ridha Fekih (CRDA), M. Rahoui (DRES), and M. Labidi (GR) in Kasserine. At the CRDA meeting with M. Mohsen Chaari and MM. Smith and Andersen of the Oregon State University team. Meeting with M. Mondher Naji, Save the Children Foundation, Kasserine. Continue preparation of the questionnaire.
9/14/83 Wed	Meeting with M. Rachid Bougatef, President-Directeur General of the CTDA. Training of the team of four interviewers, with the assistance of MM. Hussein, Sakri, and Chaari.
9/15/83 Thur	Conclude training the interviewers. Departure for Tunis.
9/16/83 Fri	Work in USAID office; begin drafting SONEDE report. Meeting with Young and Turner.
9/17/83 Sat	Rest
9/18/83 Sun	Travel to Sbeitla. Paper work in the hotel.
9/19/83 Mon	Users' Survey in Bir Guerguera (Sbeitla)
9/20/83 Tues	Users' Survey in Henchir Ali Majnoun (Sbeitla)
9/21/83 Wed	Users' Survey in Um Fadgha (Foussana)
9/22/83 Thur	Users' Survey in Ain Smiria (Sbiba)
9/23/83 Fri	Users' Survey in Ain Hajret Ettir (Thala)
9/24/83 Sat	Debriefing meeting in the CTDA, Kasserine. Departure for Tunis.

9/25/83 Sun Preparation of tally sheets from the Users' Survey

9/26/83 Mon Debriefing meeting at the USAID Mission, Tunis. Meeting with Dr. Lilia Ben Salem, Department of Sociology, University of Tunis. Departure for Cairo (arrival on 9/27).

B. Dr. William Turner

Individuals Visited:

REGIE DES SONDAGES HYDRAULIQUES
- M. Bousalem, Chef Secteur Tunisie Centrale
- M. Jafar Haj, Chef du Parc
- M. Jemaa Ameur, Chef du Service Bureau Technique
- M. Ahmed ben Amar, Drilling Superintendant, Kasserine

GENIE RURAL
- M. Mohamed Mogadi, Ingenieur

CDTA (Kasserine)
- M. Moncef Hossein, Chef du Projet
- M. Mosbah Hadji, Directeur Hydraulique
- M. Mohamed Sakri, Directeur de Planification

DRES
- M. Habib Zbidi, Director of the Water Division, Tunis
- M. Hamdene Rahoui, Director of DRES Central Tunisia Office, Kasserine
- M. Habib Alaya
- M. Ktata

SACMI
- M. Jan Montalbetti

BLOCKER ENERGY
- M. Patrick Daget

EQUIPMENT HYDRAULIQUE
- M. Mohamed Hachicha
- M. Ben Hamida

USAID
- Mme. Dorothy Young
- M. Mohamed Ali Hassairi
- M. John Rich

MISCELLANEOUS
- M. Ftouhi Jed Hedi, Director of Ain Ezzine Krib Cooperative
- M. Ahmed Ben Salah Ben Dhiaf, Operator of public well at Bin Hamaima
- M. Mohamed Labid Kalfi, Farmer at Sbiba

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APPENDIX A

USERS' SURVEY

Between September 19 and 23, 1983, a users' survey was carried out in five locations served by the potable water subproject. Altogether 83 households were interviewed in the five sites by the four interviewers trained for the purpose.

METHODOLOGY

The following comments relate to the methodology of the survey. (1) The questionnaire that was used was closely based on the one prepared by the Triangle Research Institute for the survey carried out by Dr. Raymond Isely in November 1982. (For further details, see Une évaluation des effets socio-sanitaires des sources captées pour l'irrigation adaptées a l'usage domestique en Tunisie, Rapport Préliminaire no. 120-1, Water and Sanitation for Health Project, Arlington, VA, February 1983.) His survey concerned the potable use of water from springs improved for irrigation; although our sites were designed from the beginning to provide potable water, many of the questions seemed relevant for us as well. MM. Hussein and Missaoui of the CTDA had also prepared a questionnaire in preparation for this evaluation, and some questions were incorporated from it into the one that was finally used. Two advantages of basing our work on the Isely questionnaire were that it was already prepared, and that using the same format would maximize the chances of comparison between the two studies. The questionnaire used as many closed-ended questions as

possible for ease of administration and of analysis. The questions were generally applicable to all sites where the subproject intervention had been completed, but they had to be modified in the field or skipped in cases where the work was incomplete.

(2) The interviewers were chosen from the local Service d'Hygiene (two young women) and from the local Social Affairs office (two social workers, one man and one woman.) They were trained for two days in the purpose and use of the questionnaire.

(3) The questionnaire was retyped and run off in the offices of the CTDA.

(4) The selection of the sites was done by Dr. Hopkins in consultation with M. Moncef Hussein. The sites were chosen to represent a broad range of different types -- each of the three types of intervention, and as many delegations and/or geographic zones as possible.

(5) Transportation was provided by two cars, one provided by the CTDA and the other rented expressly for the purpose.

(6) Since there was no master list or adequate map to use in drawing the sample, the team chose households on the ground by going first to the outer limit of the catchment area of the water point and then gradually working its way back to the water point itself; this explicitly introduced the factor of distance from the water point as the chief axis of differentiation. Our intent was to avoid as much as possible choosing all households from the same area (and so perhaps from the same lineage), or in such a way that some feature was overrepresented in the sample. Although our methodology

does not allow us to be sure of this, we are fairly sure that our sample is a fairly representative one. At any rate, the households chosen were from as widely a dispersed geographic area as possible.

(7) Many of the complete questionnaires were checked over at night by the survey director. All of them were summarized on tally sheets before the survey director left the country. The initial analysis was simply a straight tabulation, it being unclear whether the quality of the data fully justified a more elaborate analysis.

(8) The questionnaires were written in French, and most of the answers were recorded in French as well. However, the language spoken was colloquial Tunisian Arabic. The closed-ended nature of the questions and their fairly simple nature limited the confusion due to linguistic shifts as much as possible.

SITES

The five sites were Bir Guerguera, Henchir Ali Majnoun, Um Fadgha, Ain Smiria, and Ain Hajret Ettir, all in Kasserine Gouvernorate since that is where the activities of the subproject have been concentrated until now. Following are some notes on these sites.

(1) Bir Guerguera (15 cases; symbol BG) is located in the Rakhmat sector of Sbeitla delegation. It is an old well showing traces of Roman construction; the water table is about 65 meters below the surface. Prior to improvement, the local people drew water from the well using the dellu technique in which a donkey pulls a bucket from the well using a rope run over a pulley. This is a laborious process which requires at least two people, usually men or boys. The site is in a broad plain with some low hills in the distance. Improvement here consisted in installing a motor to lift the water, adding a reservoir to store the water, and constructing a public tap and

animal trough to provide public access. The well is supposed eventually to be covered, but was not at the time of the survey. The reservoir had taps directly on it, but these had been closed off, apparently because they were giving rise to disputes. The general impression of the people around this site is that in theory access to the water had been improved because of the motor, and there is now an advantage in that one person can do the water detail alone, but that these advantages are to a great extent cancelled out by the increased crowds that the new installations have attracted. Much of the water is hauled home using 500-liter mobile tanks pulled by donkeys.

(2) Henchir Ali Majnoun (18 cases; symbol AM) is located in the Garas al-Hamra sector of Sbeitla delegation, about half a dozen kilometers from Bir Guerguera. This is the first of the drilled wells to enter into operation, and actually even it had not fully entered into operation at the time of the survey. Initially, a temporary motor had been installed, and this had worked for a while. But the installation of the regular motor was meeting some breaking-in problems which were not solved at the time of the survey. Thus most of the people interviewed here were potential users rather than actual ones. Their complaint was that there was no water at the water point. They were therefore still using water points which were mostly on the periphery of the area, including a public tap near the Oued Miacu and another at Cebbala Ouled Asker, while others draw water from a public irrigation system. (Due to pressure of time, the researchers were unable to visit these water points to check on

the verbal descriptions made by our respondents.) The well is situated where a dirt track crosses an oued (wadi), and seems likely to serve an area forming roughly a circle around this point. However, there are some people who complain that the oued cuts them off from easy access to the point, more because of its irregular banks than because of the water in it.

Because of the distance that people must now go for water, they are mostly equipped with mobile donkey-drawn tanks holding typically 500 liters. Since most of them will still be some distance from this new well (the average distance may be reduced from 5 to 8 km to 2 to 4 km), they will continue to use this system, though those who are less than 1 km away may switch to the system in which a donkey carries two balanced barrels or jerrycans. They also may elect to remain with the mobile tanks. There are two implications of the this system. (1) Most households have a cistern in the ground near their house for storing water brought by the mobile tanks. The cleanliness of this majen must be maintained to ensure that the water actually consumed is still clean. (2) Fetching water with a mobile tank is essentially a job for men and boys. If the atmosphere at the Henchir Ali Majnoun is dominated by males, then even those households that are nearby will be reluctant to send their females to fetch water.

(3) Um Fadgha (19 cases; symbol UF) is located northwest of Foussana town in Foussana delegation. This is a drilled well that is not yet functioning because the civil engineering works have not been completed and the motor has not yet been installed. The civil engineering works were delayed when some members of the local population protested that to place the reservoir and public tap next to the

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well site would make it too far from the principal population to be served. As a result a two km pipeline is now being laid to a new site for the reservoir, somewhat closer to the houses of those who complained. Here, too, we interviewed mainly potential users rather than actual users, and the responses relating to drawing water refer to the traditional water points used in the area. The well site and the reservoir site are both in a broad plain that slopes down to the Oued Hatab, and are both located a few meters from a dirt track that parallels the railroad line. The traditional water points include some springs in the hills overlooking the plain, and the Oued Hatab itself. The springs are difficult of access and frequently have too many users, especially in the summer. The Oued Hatab water can be used for animals, but the people only use it for themselves as a last resort. A few people mentioned using drilled wells.

Because people mostly get their water from springs located in the hills, the donkey-drawn mobile tank is not as common here as in the two previous cases. Most people use donkeys with a pair of barrels or jerrycans. The water haulers are generally teenage girls who accompany the donkeys, and sometimes animals that need to be watered, to the mountain springs such as that of Deshrat Sidi Bou Ghanem. There in the summer time they must use several smaller containers to fill their barrels or jerrycans, first using a dipper to fill a bucket, then climbing out of the spring area to the waiting donkey to empty the bucket into the barrel. (Again we are judging by informants' accounts rather than by observation.)

(4) Ain Smiria (16 cases; symbol AS), is located near Sbiba in Sbiba delegation. This is a case of an improved spring. The spring was captured and the water fed into a tap and animal trough about 100 meters away, at the edge of a small wadi bottom. The bulk, maybe even the totality, of the users of this spring are from the settlement of the same name, composed of people bearing the lineage name of Smiri. Thus here there is a form of "natural" community. The people live on a series of small ridges that run down from the mountain towards the plain of Sbiba, where the irrigated perimeter is located, and the spring is in a cleft between two of these ridges. Many of the men work in the irrigated perimeter, either as farmers or as workers. The community is the only one in the sample to be electrified, due to its proximity to the paved road and to the town of Sbiba itself (about 3 km away). Half the households interviewed here had television sets, compared with 7 of 67 in the other four areas combined.

The people of Ain Smiria took their water from the spring both before and after the improvement. In general they recognize an improvement in the quality of the water, and somewhat easier access, but remain convinced that the capture of the spring has resulted in reduced flow. Most water is hauled by teenage girls, sometimes using donkeys, sometimes hauling a single jerrycan with a tump line around their forehead to support the weight. The spring is definitely a "feminine" spot, and the women and girls tend to scatter whenever a man approaches the spring.

Ain Smiria has alternative sources of water. There are other

springs and wells in the area, although they tend to have a miniscule flow and/or salty water. Some families send their teenage boys to a "sondage," almost certainly intended for irrigation in the perimeter; here there is a masculine atmosphere, and water may be hauled in larger containers including mobile tanks. Women sometimes take their washing down to the irrigated perimeter where they use water drawn from the open irrigation canals; some animals are also watered in this way. Thus this case illustrates the ability of people to discriminate and choose among a range of possible water sources, valued according to their usefulness for different tasks and perhaps according to whether the family has a girl or a boy available to fetch the water. Perhaps for this reason, Ain Smiria had the biggest variety in types of containers used to fetch water.

(5) Ain Hajrat Ettir (15 cases; symbol HT), is located at the base of a ridge in the extreme southern part of Thala delegation, overlooking the Foussana plain. The spring was captured and fed into a storage tank about 50 meters further down the slope. The storage tank was built here because the flow of the spring is low and this allows the night flow to be collected for use the next day. Consequently, the reservoir has a tap that must be opened for the water to flow out. Apparently this spring was essentially used to water animals before being improved, so that the new installations made the water accessible for human use for the first time. Previously people in the immediate area had mostly gone to the Oued Tarfaya (about 3 km away) for domestic water. After the improvements, they switched and began using this spring for domestic use and taking their animals

to the Oued Tarfaya. However, there were some complications in the pattern caused by oueds that might be impassible in the winter, and the difficulty of reaching the Ain Hajrat Ettir itself -- this involves descending a relatively steep slope. Of the five cases surveyed, this one appears to have the smallest catchement area. Most of those who used the spring live in the immediate vicinity. Although there was some expectation that people from another hillside across the valley would also come there is no indication that they ever did.

These sentences are phrased in the past tense because sometimes during the summer of 1983 the tap on the reservoir was broken. As mentioned elsewhere, this breakage may be linked to the conflict between the large local landowner and the surrounding population over access to the improved water point. It can now be opened only by those who have figured out the trick. Consequently, people have now reverted to using the Oued Tarfaya, both for domestic uses and for animals, or other water points in other directions. What will happen when the winter rains augment the flow is unclear. Some people talked as though leaving the Ain Hajrat Ettir in the summer was a normal thing, and this might well be the pattern. This pattern of usage means that people's answers sometimes referred to the spring and sometimes to the Oued Tarfaya or another water point, because the spring itself was no longer accessible.

RESULTS

(A) Household size. Altogether the 83 households we interviewed contained 501 individuals, giving an average household size of just over six people. But this figure does not adequately reflect the

structures of the extended family, fairly common in the region. It is clear that sometimes the interviewer only recorded data relating to one nuclear family in an extended family household. Especially in the first three sites, it was obvious that several related families -- headed by brothers or by fathers and sons -- live near each other and operate as a single unit in some respects, including hauling water. Therefore, our survey should probably have made an effort to include all information relating to the extended family in order to gauge water use and the availability of individuals to fetch water. The constituent parts of a nuclear family can have a variety of different links with one another, especially in areas like these where "tribal" organization means that neighbors are almost always close kinsmen anyway. We did not know enough about the local situation to formulate field instructions precisely, and in any case the questionnaire did not call for a thorough delineation of household membership. Therefore, the figure of six persons per household should be taken as a minimum figure.

(B) In the total population sampled there were 33 nursing babies and 85 other children under the age of 6, for a total of 118 (24%). School-age children (6 through 14) were 174 (35%). The percentage of the total is higher than in the Isely sample (52.5%). Of the pre-school-age children, 73 (62%) were reported to have suffered from diarrhea during the preceding week, and 33 (30%) were reported to have some sort of skin infection. Of the school-age children, 25 (14%) were reported to be suffering from skin infections. These figures are considerably higher than those recorded by Isely. Isely's overall figures are that 44% of the young children suffered from diarrhea (34% in areas with improved springs), and that 22% of all

children under 15 suffered from skin diseases (19% in areas with improved springs). Table 1 gives some further information from our sample concerning the distribution of diarrhea by household.

TABLE 1: Diarrhea cases by survey site

Site	Average	No Case	
BG	1.5	2	13%
AM	1.1	4	33%
UF	1.2	1	8%
AS	1.2	3	30%
HT	1.3	0	0

(1) Average: Average number of case per household with children under 6.
(2) No Case: Number and percentage of such households with no case.

These data suggest that while diarrhea is a problem everywhere, it is relatively less of a problem in Henchir Ali Majnoun (AM) and in Ain Smiria (AS), and relatively more of a problem in Bir Guerguera (BG) and in Ain Hajrat Ettir (HT).

One question in the questionnaire asked people to compare their perceptions of the incidence of water-borne diseases before and after the improvement of the water point. Naturally, we could not ask these questions in AM and UF. In the three sites where the questions could be asked, most people of course said that they did not know or that there was no difference. Leaving out "don't knows" and "not applicables", the figures for BG, AS and HT are given in table 2.

TABLE 2: Perception of change in health conditions

More Diarrhea	9	26%
Equal Diarrhea	23	68%
Less Diarrhea	2	6%
More Skin Infections	14	38%
Equal Skin Infections	22	59%
Less Skin Infections	1	3%

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These answers would have to be discouraging to those who hope that improved quality of potable water will also lead to improvement in health conditions. It may be that the perception was affected by the fact that our survey was done at the end of the summer, when water quality and quantity are at their lowest, or it may simply be that the improvements have not been around long enough for people to have formed an accurate opinion. Opinion ran more strongly negative in AS, where people feel that the spring now yields less water, and in HT, where there are problems with the tap, than in BG, the most recently improved of the sites. But the numbers are too small to be fully indicative, and in any case we are dealing with perception, not reality.

In the Isely sample, most people saw no change in the incidence of disease, but those who did notice a change were at least twice as likely to see it as a change in the direction of fewer health problems. Again, one cannot eliminate seasonality or the longer time period between improvement and interview as reasons for this difference.

(C) In asking people the frequency with which they washed their hands, bathed, washed clothes, or washed the dishes, we used a code to indicate they did the activity more than one time in the period specified, one time only, or less than one time. This proved not to be fully diagnostic. Virtually everyone said they washed their hands more than once a day, bathed more than once a month, washed their laundry more than once a week, and washed the dishes more than once a day. The biggest exception to this pattern was washing the dishes, which some people said they only did daily. These statements testify to a desire to use water to keep clean, and

indeed, it is my impression that the houses we visited were generally kept quite clean. Most people said they performed these tasks at home. Not surprisingly, washing clothes is the task most frequently reported (74%) as being done at the water point (although not always at the water point from which domestic water is drawn, as in AS). The other three tasks were performed at home in 89% to 94% of the cases. Only one case in AS reported always washing clothes at the water point (the irrigation canal in this case). In all other cases, the answer was sometimes at home, sometimes at the water point.

(D) At this point in the questionnaire we asked people whether they generally felt that they had more than enough water, enough water, too little water, or much too little water for their needs. The figures are given in Table 3.

TABLE 3: "Do you have enough water for your needs ?"

	SITE						
	BG	AM	UF	AS	HT	total	%
More than enough	2	-	-	3	2	7	9%
Enough	10	10	5	9	9	43	54%
Too little	3	6	9	4	4	26	33%
Much too little	-	-	1	-	-	1	1%
1 & 2	-	1	-	-	-	1	1%
1 & 3	-	1	-	-	-	1	1%
No answer	-	-	4	-	-	4	
total	15	18	19	16	15	83	N: 79
average answer	2.06	2.3	2.7	2.06	2.13		

The answers here suggest that most people are satisfied with the amount of water that they are able to get -- almost 2/3 of the respondents say that they have enough or more than enough water for their needs. Of course, one might also interpret the answers to mean that people have

scaled their needs down to match the water they are able to haul home. But the differences between the sites argue against this. Only at Um Fadgha did more people respond that they had too little water, and we shall see that this corresponds to the actuality: the people in the Um Fadgha area report the least amount of water carried home. Curiously, the next highest level of dissatisfaction is in AM, where people report by far the most water brought home. Despite their problems, the only sites where some people reported that they had more than enough water are the three where the subproject interventions had actually been completed prior to the survey.

(E) Most people reported that they had soap in the house (84%). Of those without soap, 5 were at the Um Fadgha site, 3 each at AM and HT, and 2 at AS. Everyone at BG reported having soap. In some cases people distinguished between cake soap and "Omo", used for washing clothes. Households do not always have soap all the time because it may take several days to resupply if they run out between market days. Among our respondents, 73% said they used soap to wash their hands all the time, with the remainder evenly split between those who do not use soap and those who use it sometimes. There also seemed to be a wry recognition that children do not always do as well at washing their hands with soap as they are supposed to.

(F) We asked people where they had their animals drink. The results are given in Table 4.

TABLE 4: "Where do you water your animals ?"

	SITE						
	BG	AM	UF	AS	HT	total	%
no animals	4	1	5	5	6	21	25%
at home	5	14	3	5	2	29	35%
take them to water point	4	3	1	3	3	14	17%
take them elsewhere	2	-	9	3	4	18	22%
home & water pt.	-	-	1	-	-	1	1%
TOTAL	15	18	19	16	15	83	100%

The answers reflect a variety of different ecological circumstances. The high figure for watering animals at home in AM reflects their distance from a watering point and the presence of many mobile tanks which allow them to haul the water relatively conveniently. The animals that are taken to a water point other than the one used for domestic water are usually taken to a oued (BG, UF, HT) or sometimes to an irrigation canal (AS).

Among our respondents, 50 reported the presence of sheep, 18 that of cattle, and 11 that of goats, with some overlap. The figures in Table 4 suggest that about 3/4 of the households possess some domestic animals. But it is possible that we missed some because they are considered to belong to another nuclear family in the extended family, or because they do not "belong" to the person interviewed, but are merely held on behalf of someone else. Since we were concerned with work and water and not with wealth, we tried to include these cases, but undoubtedly some escaped us.

(G) We asked people whether it was easier in the past or the present, before or after the improvements, to fetch water from the water point, and whether they felt they were getting more water or less. Naturally these questions could not be asked at UF, where the intervention was not complete, and they only partially made sense at AM. The results of these questions are given in Table 5.

TABLE 5: Comparing the Water Point Before and After

	SITE					
	BG	AM	AS	HT	total	PC
a. Fetching water						
Much Easier	4	2	5	6	17	35%
Easier	5	-	7	6	18	38%
Harder	4	5	3	-	12	25%
Much Harder	-	1	-	-	1	2%
No Answer	2	10	1	3	16	-
b. Amount of Water Available						
Much More	-	-	4	2	6	12%
More	3	4	1	7	15	31%
Less	8	6	10	2	27	55%
Much Less	1	-	-	-	1	2%
No Answer	2	8	1	4	15	-
c. Water Actually Brought Home						
More	4	2	-	5	11	24%
Same	5	-	3	-	8	17%
Less	4	4	13	6	27	59%
Don't Know or Remember	1	4	-	-	5	
No Answer	1	8	-	4	13	

Where interventions have been completed, people generally are content with them, but they remain very much aware of certain problems, such as broken taps and unreliable motors. Generally they are more likely to find that access is easier (73% of answers) than to find that the amount of water has increased (43% of answers). This distinction reflects the extra crowds that have been attracted in BG, the broken tap in HT, and the already mentioned feeling that less water is now available and brought home. People feel that access would be easier if there were not these problems.

Further refinements come from another set of questions asked later in the questionnaire. Here people were asked whether it was easy for them to approach the water point, and whether it was easy

to draw water. Then they were asked to compare the present state with the situation before the improvements. Again these questions were not asked at UF, and the comparative questions when asked at AM were not answered or answered in a way that suggests the questions were misunderstood (several people answered that access and drawing water were both harder now, perhaps referring to the break after the replacement of the first motor). The results are in Table 6.

TABLE 6: Ease of Use Before and After the Improvement

a. Ease of Access

	SITE				
	BG	AM	AS	HT	total
Very Easy	8	10	8	5	31
Easy	4	4	7	6	21
Hard	2	-	1	-	3
Very Hard	-	1	-	-	1
No Answer	1	3	-	4	8

b. Ease of Drawing Water

Very Easy	8	9	9	5	31
Easy	-	4	4	4	12
Hard	6	-	3	2	11
Very Hard	-	2	-	-	2
No Answer	1	3	-	4	8

c. Access Easier?

Easier Now	7		9	4	20
Same	2		2	-	4
Harder Now	4		5	4	16
Don't Know/No Answer	2		-	7	9

d. Drawing Easier?

Easier Now	4		6	3	13
Same	2		2	1	5
Harder Now	8		7	4	23
Don't Know/No Answer	1		1	7	9

Again we see that people appreciate the work that has been done in one sense. Of people from the four sites, 81% found that access was easy or very easy, and 67% found that drawing water was easy or very easy. Leaving out the "don't knows", we note that half the people found that access is easier now than before, but that only 1/3 (32%) found that drawing water is easier now than before. This patterning of answers reflects the same situations already referred to above.

Generally speaking, people are more pleased with the access than with the ease of filling their containers. They give higher marks to the new installations if they do not compare with the past. The opinions reflect (perceived) real difficulties in BG (too crowded), in AS (flow allegedly reduced), in HT (broken tap), and in AM (not yet functioning).

In the Isely sample of springs improved for irrigation but also used for domestic water, 54% of the respondents found that access to the improved spring was easy, and 62% found that drawing was easy. This contrast is due in part to the particular physical construction of the irrigation springs. About 2/5 of the people found that both the access (41%) and the drawing (38%) had been made easier by the improvement, while 37% of the people reported that they brought more water home after the improvement than before.

We were also interested in the way in which people hauled water from the water point to their homes, and the amount that they hauled. The method differed characteristically between the different water points which we examined. As Table 7 makes clear, BG and AM rely essentially on the 500 liter mobile tank pulled by a donkey, while

the other three sites generally make use of the donkey to carry a pair of barrels or jerrycans. (The barrel and the jerrycan answers are essentially the same in that both normally involve a pair slung over the back of the draft animal; the difference is only in the size and origin of the container.) In AS where some girls carried the water themselves there was a wider variety in the kinds of containers used.

TABLE 7: Type of Water Container Used

a. How do you fetch water from the project water point?

	BG	AM	UF	AS	HT	total	%/55
barrel	2	1	-	-	2	5	9%
jerrycan	1	2	-	11	10	24	44%
pottery jar	-	-	-	3	-	3	5%
goatskin	-	-	-	7	-	7	13%
bucket	-	-	-	5	3	8	15%
mobile tank	11	12	-	2	-	25	45%
no answer	1	4	19	1	3	28	--
total answers	15	19	19	29	18	100	
total cases	15	18	19	16	15	83	
positive ans.	14	14	-	15	12	55	

b. How do/did you fetch water from the other water point?

							%/44
barrel	-	-	10	-	2	12	27%
jerrycan	-	-	9	-	8	17	39%
pottery jar	-	-	-	-	-	-	-
goatskin	-	-	-	1	-	1	2%
bucket	-	-	1	-	-	1	2%
mobile tank	-	14	-	-	-	14	32%
no answer	15	4	-	15	5	39	
total answers	15	18	20	16	15	84	
total cases	15	18	19	16	15	83	
positive ans.	-	14	20	1	10	45	

Table 7b combines responses from UF, where no one yet took their water from the subproject water point, and from AM and HT, where people still for a variety of reasons relied on their old water point. In BG and in AS, most of the answers referred to the existing water point

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which had been improved. By combining the results of these two tables we see a definite pattern. The two areas that are relatively flat (BG and AM) make extensive if not exclusive use of the mobile donkey-drawn tanks; in the areas where most people get their water from springs, these are less used and may be less useful because of the hilly terrain and the relatively difficult access of the springs themselves.

Table 8 gives the breakdowns for the respondents' estimates of distances between themselves and the water point. Since these figures were not independently checked, they should not be taken literally, but may indicate an order of magnitude or at least a psychological state. The figures show that the people of AM and of UF are the big "travellers" in this respect. The average distance estimated by the people at UF was 4,610 meters, while at AM it was 4,370 meters. In the other open plains area (BG), it was 2,130 meters. In the two springs areas, it was less than one kilometer -- 940 meters at AS and 700 meters at HT. The overall average is 2,815 meters. It should be remembered that the figures for UF (always) and AM (mostly) indicate the distance to the "old" or non-subproject water point. Thus one can assume that once the new drilled wells are fully operational, these distances will be reduced. On the other hand, the distances to the dug well and the springs were of course unchanged by the improvements.

For AM and UF we recorded a number of alternative water points, those that they were using while waiting for the new installations to be completed. Those most frequently cited at Henchir Ali Majnoun were a oued (perhaps a well at a oued) to the north of the new water point, and an irrigation perimeter to the west. At Um Fadgha they were the spring at Deshrat Sidi Bou Ghanem and the Oued Hatab. At Ain Hajrat Ettir, the alternative sites mentioned (a nearby oued and

a well improved by CARE-Medico) were used before the improvement of the spring or after its blockage, or in some cases together with it according to the seasonal variation in the flow. At Ain Smiria the alternative sites were mostly used to supplement the water from the spring, as for instance in the case of water from the nearby irrigation system used for animals and for washing clothes. At Bir Guergeura, the alternative sites were mentioned by those living on the catchment area, who also made choices according to circumstances.

TABLE 8: Distance from the water point

	BG	AM	UF	AS	HT	total
Less than 500 m	1	1	1	4	3	10
500-999 m	1	-	1	3	6	11
1000-1999 m	4	-	-	5	3	12
2000-2999 m	3	4	2	3	-	12
3000-4999 m	4	3	6	-	-	13
5000-6999 m	1	8	6	-	-	15
7000-9999 m	-	2	2	-	-	4
10,000 m & over	-	-	1	-	-	1
total	14	18	19	15	12	78
average (km)	2.1	4.4	4.6	.9	.7	2.8

Finally from the information people gave us concerning the containers they used and the number of trips per day or per week they made it was possible to derive a rough estimate of the amount of water brought home from the water point. These figures are given in Table 9. They indicate that the big water users are in AM, and the users of least water are in UF (where the drilled well may improve matters once it begins to operate). One conclusion is that people who use the mobile tanks bring more water home, but they are also more likely to use it for watering stock at home and even for some irrigating of fruit trees. To this extent, the amount of water that reaches the house is a function of the technology used to haul it.

However, the figures may be misleading in that we did not fully distinguish the size of the group that is served by each case. It may be that the larger amount of water per case reported in AM reflects the fact that several related families, perhaps even an extended family, are sharing the water brought home in a single tank, whereas in UF, because the technology does not allow much water to be brought home at once, each nuclear family must look after itself. Even taking all these factors into consideration, it is surprising that the people around AM report bringing home ten times as much water as those in the UF catchment area -- especially considering that in both cases the figures reflect conditions prior to the operation of the new drilled well.

TABLE 9: Estimates of water brought home

	BG	AM	UF	AS	HT	total	%
Less than 100 liters	2	1	13	4	4	24	31%
100-199 liters	3	2	4	6	9	24	31%
200-499 liters	4	2	2	3	1	12	15%
500-999 liters	4	3	-	2	-	9	12%
1000-1999 liters	-	7	-	-	-	7	9%
2000 liters and over	-	2	-	-	-	2	3%
total answers	13	17	19	15	14	78	
average (liters)	285	904	90	185	127	325	

Most people were satisfied with the quality of the water they were able to bring home. Thus overall 34% found the water was very clean and 55% found that it was clean, while 90% of the respondents considered their water to be sweet. Most of the dissenters were probably commenting on water drawn from non-subproject sources -- these from the Um Fadgha area, for instance, include 4 of the 9 who found that the water was dirty or very dirty, and 4 of the 8 who found that it was salty.

Other dissenters were from the Ain Hajret Ettir and from the Bir Guergeura catchment areas. Those from Ain Smiria universally found that the water was clean or very clean, and that it was sweet, and so did most of those from Ain Hajrat Ettir (where the others may have been thinking of water from the Oued Tarfaya or elsewhere).

The relative failure of the Hygiene Service to contact families around the new or improved water points is shown by the fact that 94% of the households reported no such contact. It may be that the visits of the Hygiene Service have been restricted to contacts at the water points themselves. If so, it may be suggested that this is a poor way to have an impact. Even the five respondents who said they had been contacted fit no single pattern, and it may be that even here there is a misunderstanding. The first, at BG, said that the Hygiene Service had come but had offered them no advice concerning the cleanliness of the water (they appear to have been testing the quality of the water in the cistern). One respondent in AM said that the Hygiene Service had visited them three times since the construction of the new site, and that they had received advice on hygiene which they followed because it was good: the respondent was anxious to impress on us that cleanliness is now practiced by the women of his household. Another respondent in AM said that the agents had given him advice concerning the home cistern which he did not follow because he did not have a home cistern. One person in UF said that they had received advice on how to improve care for diarrhea and skin infections. Finally, one person in AS said they had been visited but provided no further information. The lack of geographical concentration of these answers does not reflect a concerted effort to

spread better health ideas.

Finally some indication of the general socioeconomic level of the population surveyed can be gained from Table 10, which indicates the level of education attained by the most educated member of the household, and the livestock holdings of the household, as well as the possession of such key items as a mobile tank, a radio and a television set.

TABLE 10: Socioeconomic indicators

	BG	AM	UF	AS	HT	Total
No education	5	7	7	4	8	31
Some education	7	4	8	3	6	28
Finished Prim. Sch.	1	1	1	2	-	5
In Sec. Sch.	1	3	1	7	1	13
Sec. Sch. or more	1	2	-	-	-	3
No answer	-	1	2	-	-	3
possess cows	-	4	5	5	4	18
possess sheep	9	17	14	5	5	50
possess goats	2	-	5	1	3	11
possess mobile tank	9	13	-	2	-	24
possess radio	9	10	6	8	6	39
possess TV	2	2	2	8	1	15

The educational level does not appear very high. While 26% have someone in the family with a primary certificate or above, 37% say that no one in the household at all has any education. Considering the effort given to improving access to education in Tunisia, this figure suggests that we are dealing with a particularly isolated population. The tables for livestock and material possessions include some multiple answers. Sheep are the most common animal held. Sheep are relatively more freqently held by the people in the catchment areas of the three wells than of the two springs. Cattle are evenly distributed except that no one at BG reported any. Radios are more or less evenly distributed, but television sets are concentrated at Ain Smiria, the only one

of our sites to have electricity.

CONCLUSION

1. In general, the survey results show that where the subproject interventions have been completed, people are generally satisfied with them. However, there are some problems where unexpected developments have occurred. Some of these, such as the extra crowd at BG, may be temporary. Others, such as the belief in AS that the flow is reduced, may be expected to remain as ideas since there is nothing that will refute them. However, such ideas may be dangerous if they incite people to damage the new installations in the process of trying to recover the flow they believe they had in the past, or because of frustration.

2. The amount of diarrhea perceived is higher than that recorded by Isely for November 1982 in different sites. The explanation is uncertain. It could be due to many things, including simply a different season of the year (the end of summer versus the early winter rains). Our sample was also somewhat inclined to think that the health situation had worsened since the intervention, but these answers may reflect local non-health conditions.

3. People say they make considerable use of water, in a genuine effort to keep clean.

4. Most people say they have enough or more than enough water for their needs. The exception is at Um Fadgha.

5. Almost half the people with animals water them at home. The others are more likely to go to a water point (e.g., a oued) different from the one they use for domestic water.

6. Generally speaking, people are more pleased with the access

than with the ease of filling their containers, though both receive positive comments.

7. The two most common ways of bringing water home are the pair of containers slung across the back of a donkey on the one hand, and the mobile tank on the other. The choice between them may be dictated by terrain (flat versus hilly) as much as anything.

8. At the moment the longest distances travelled for water were at AM and UF, the two sites where drilled wells are nearly completed. In both areas the average distance was over 4 km. This will presumably be reduced once the new wells enter into full operation.

9. The amount of water brought home differs by a factor of ten. The difference (if it reflects anything more than a way of answering questions) reflects the use of mobile tanks and the habit of watering the animals at or near the home in AM, compared with donky-borne containers and watering the animals at the oued in UF.

10. If the educational indicator is any guide, then our target population is truly underprivileged by Tunisian standards.

APPENDIX B

COMMENTS ON DRILLING, PUMPING, AND SITE SELECTION

According to the scope of work, the objectives of this Interim Evaluation are to:

A. Evaluate the performance cost and effectiveness of drilling operations under AID project 664-0312.7 using the TH-60 drilling rig as compared with

1. other drilling operations in Tunisia by the same drilling institution,
2. other drilling companies in Tunisia, and
3. drilling in other countries.

B. Evaluate the extent to which the purpose of introducing lower cost drilling technologies is being achieved and/or is a realistic, attainable purpose in Tunisia based on the findings in A above.

C. Make recommendations for improving the management of the rig to control and reduce downtime.

D. Evaluate the cost effectiveness and appropriateness of pumping equipment installed or to be installed at the surface and drilled-well sites.

E. Evaluate the quality and appropriateness of the construction and design and a sampling of each type of intervention and recommendations for changes if appropriate.

After providing some background, we will look at each of these questions in turn.

BACKGROUND

The Central Tunisia Rural Development (CTRD) Program is an integrated program seeking to bring about improvement in the quality of life of the more than 200,000 estimated inhabitants of nine delegations located in Central Tunisia. The CTRD Program is involved in agricultural development, public health improvement, extension and training programs and the development of potable water supplies. The principal partner of the CTRD Program is the Central Tunisia Development Authority, with headquarters in Kasserine.

In the area of potable water supplies the U.S. Agency for International Development (AID) has funded various types of programs. The SONEDE projects funded by AID initially were concerned with providing water from springs and drilled wells to communities with populations over 3,500 individuals. The CARE/Medico-OPG programs were designed to assist more scattered populations through improvement of shallow wells, development of spring sources and the construction and/or rehabilitation of large diameter dug wells. The SONEDE projects have consistently received high marks for project planning, implementation and completion. The CARE/Medico projects involving the sealing of wells for sanitary purposes and the installation of hand pumps have met with failure reflected in the outright destruction of some of their works by the local population. Every evidence suggests that the spring development and well rehabilitation measure have been accepted, although AID no longer supports the handpump program.

Where rural areas contained from 500 to 3500 persons, however, no cost effective program existed. In 1978 Louis Berger, Inc. and AID Consultant Lester Maupin suggested the use of drilled wells to fill the gap. The wells could be mechanized and the water distributed by public fountains. The intent was to get away from large bore deep wells mentioned in the Berger report. The 664-0312.7 Project paper emphasizes lower cost well technologies such as the use of smaller, more mobile and cost efficient rigs for drilling shallow or medium depth wells. The project document goes on to advocate a rig capable of drilling such wells plus the supporting services of two technical experts, a well driller and hydrogeologist. Some of the wells were intended to be equipped with handpumps.

In 1980, Dickson et al presented their report entitled "Potable Water for Dispersed Populations in Central Tunisia". This document is an extremely thorough treatment of the institutional framework within which potable water projects would operate. It is also a comprehensive treatment of all aspects of groundwater availability and drilling technologies. Certainly this report could be added to but it hardly seems worthwhile repeating any of the information contained in the report.

In the three years which have passed since the preparation of the Dickson report, projects have been implemented and completed and a track record now exists. It is the purpose of the present evaluation to determine if there are feasible methods of accelerating the rate at which potable water supplies are brought to the rural areas and at the same time reduce costs.

As a result of the Berger, Maupin, and Dickson and Glaze reports, AID decided to fund hand-dug well and drilled well projects. The RSH was contracted to carry out the well drilling. CTDA was informed by RSH that it had some 15 wells already backlogged and that it could be a year before it had equipment free to drill for the project. AID agreed to purchase a drilling rig.

The rig selected was a TH-60 Cyclone drilling rig manufactured by Ingersoll Rand. The TH-60 came with 41 joints of 4.5 inch drill pipe, a 5x6 mud pump and a 750+ 225 air compressor. The TH-60 is a sophisticated top-head-drive hydraulically powered drilling machine and it is the only one of its kind in Tunisia. It is intended for drilling small diameter holes of not more than 8-inches in diameter to depths of not more than 600 feet using either mud rotary or air hammer methods. Maupin had early recognized the usefulness of air hammer methods. The TH-60 is really intended to use an air hammer in hard formations rather than tricone bits.

It was early determined that the CTDA which had primacy for the execution of the project did not have the technical capability to operate the rig and it was determined that RSH should operate the rig for the project and bill the project for time and materials as it normally billed other government agencies except that the CTDA potable water project would receive a discount of about 30 percent on drilling costs inasmuch as the rig was provided by an outright grant.

To ensure that personnel were properly trained in the operation of the rig, Ingersoll Rand provided two senior drillers for a period of six months to train the drilling crew. The crew consists of two drillers, plus mechanics, drivers, and helpers totalling about 10

individuals. This is in comparison to a normal two or three man crew which would operate this equipment in the United States.

(a) COST EFFECTIVENESS

1. DRILLED WELL COSTS

It is difficult to compare well costs from one country to another because of the numerous factors for which no information is available. Such items may include:

1. Taxes, import duties, and other imports.
2. Experience of crews with similar equipment.
3. Well drilling and construction predelictions of drillers and supervisory personnel.
4. Cost of labor and number of laborers in crews.
5. Drilling practices.
6. Geology at the drill site and distance to water.
7. Availability of spare parts and competence to make repairs.

Also, in the drilling and construction of wells, there arise certain vicissitudes which are unforeseeable and unavoidable. These may include:

1. Mechanical problems with the rig.
2. Lost circulation with insufficient water and lost circulation materials present.
3. Twisted off drill pipe which may require fishing jobs.
4. Heaving formations which tend to squeeze off the hole.
5. Steeply dipping rock strata which may lead to crooked holes into which casing may not be placed.
6. Sand finds its way into bearings.
7. Ruptured hydraulic lines.

In an attempt to arrive at drilling time and costs and well construction time for well construction in other countries, drilling and construction time and total cost have been obtained from a number of sources for:

1. Three wells in Ecuador
2. Five wells in the United States
3. 23 wells in Morocco
4. Six RSH wells drilled with their mud rotary equipment.
5. Five wells drilled by Equipement Hydraulique with their mud rotary equipment.
6. Eight wells drilled by RSH using the TH-60
7. One well drilled by Blocker Energy Co. using an Ideco Rig.
8. One well drilled in the United States using a TH-60 subsequent to field work on this project by one of the team.

To compare performance, the time required to drill out one cubic meter of earth was calculated for each well for which information was available. The total cost to drill out one cubic meter earth was also calculated. These parameters were used because it is not valid to compare the cost of a 200 metre 6-inch diameter well with a 200 meter 12.25-inches diameter well. The large hole requires removal of four times as much earth and the drilling time may be four times as long, hence higher total wages and other rig operating charges.

Cost data for Moroccan and Tunisian wells were brought up to date by escalating costs at seven percent per year converting to dollars at the prevailing exchange rate for mid-September 1983.

Costs for wells drilled in the United States were also escalated at seven percent annually to arrive at current estimated costs.

All time and cost information is summarized in Table 1.

It is not possible to make any quantitative judgements from these data. It is only possible to draw some general conclusions.

1. The time required to drill out the cubic meter of material is a rough estimate of operator efficiency and rig performance. In Tunisia, well construction procedures have been rather standardized by DRES and RSH. The TH-60 operated in Tunisia appears to operate much more efficiently than any of the rotary equipment presently operated by RSH and for which data was made available by RSH. The TH-60 also seems to outperform rotary equipment operated by Equipment Hydraulique, a private firm.

2. The TH-60 operated by RSH seems to be operating with about the same degree of efficiency as a TH-60 operated in Ecuador.

3. Ecuadorian drilling methods and Tunisian methods are somewhat less efficient than mud rotary methods employed in the United States.

4. The cost to drill out one cubic meter of earth seems to decrease with deeper wells. Cost per cubic meter has factored into it hole dimensions so that the numbers are comparable but only as good as the data upon which they are based. Intuitively one expects that the relationship has certain fixed costs, such as mobilization and demobilization associated with it. These costs are present regardless of well depth and as well depth increases, they decrease on a unit depth or unit volume-of-material-removed basis.

Table 1. Time and cost information for drilled wells in the United States, Ecuador, Tunisia, Upper Volta, Ethiopia, and Morocco.

Country	Well Depth (M)	Average Diameter (MM)	Hours per Cubic Meter	Dollars per Cubic Meter	Discharge Rate (L/S)	Average Well Cost ($)
Morocco	178	464		6161	58	185,178
United States	518	292	2.18	2142	50	73,402
United States	200	152	1.73	2608		10,000
Tunisia (EH)	128	444	52.14	4640		91,957
Tunisia (RSH)	236	408	28.27	2586		79,790
Tunisia (TH-60)	184	377	9.37	1259	30	46,369
Tunisia Blocker	400	444	5.81	3634		225,600
Ecuador (TH-60)	110	572	5.08			
Upper Volta	80	203	1.54			
Upper Volta	80	203	1.74			
Ethiopia (TH-60)	80	331	2.87			

5. The cost to drill wells in Tunisia using the TH-60 are probably more or less in line with drilling costs for the rest of the world. The costs appear to be less than experienced by RSH for their other wells. This may be due to lower wages paid to government drillers, (though this is unsubstantiated), even though there are more of them and the fact that charges for rig time are reportedly reduced by 30 percent by using government equipment.

6. The IDECO rig operated by Blocker Energy and Le Forage is operating at a cost which is also in line with costs encountered elsewhere. This is particularly significant inasmuch as the Blocker operation is a first class operation running 24-hours per day.

7. The Abiquiu lot 23 well drilled by American Ground Water Consultants to a depth of 200 meters subsequent to field work on this project using a TH-60 and an air hammer significantly outperformed all other equipment listed.

In the above analysis, it should be remembered that the TH-60 operated by RSH for the project has no air hammer capability. The addition of this capability would be to the advantage of the project because of the rather indurated character of some rock in which the rig must operate. It is likely that the performance of the TH-60 using the air hammer will increase dramatically over present performance.

Based on time and cost data, the TH-60 appears to be operating satisfactorily when compared to operations of other mud rotary equipment operated elsewhere.

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2. DUG WELLS

Large diameter dug wells are also being used for potable water supply. Dug well cost data have been provided by the irrigation and potable water branches of CTDA and from historic information obtained in Morocco for similar wells. The CTDA finances self help well digging projects in the irrigation sector. Loans are made available to individuals to pay for materials and labor for the construction of the well after the individual has proven clear title to the land on which the well is to be dug. The dug wells constructed under the irrigation program contain no on-site storage or fountains or animal watering troughs. The CTDA potable water program contracts with outside entrepreneurs to dig the wells and to construct the water fountains and animal watering troughs. The overall costs of the two types of wells are therefore different. Relevant cost information for dug wells is presented in Table 2.

The costs for excavation and civil works for dug wells for the potable water wells in Jelma, Rohia and Makthar were obtained from CTDA. The cost of $74.39 (US) per cubic meter of excavated material is equivalent to about 52.76 Tunisian Dinars per meter depth of the wells. This is compared to 150 TD which the CTDA budget allows for these kinds of wells. This price is compared to the cost of 50 TD per meter quoted by M. Mohamed Labid Khalfi at Sbiba. The site under construction by M. Khalfi was visited by the team. M. Khalfi reports that his material costs are 30 TD per meter and his labor costs are 20 TD per meter. This site contained a few lessons which may be helpful to the project.

Table 2. Cost information for dug wells in Central Tunisia and Morocco.

Country	Number of Wells	Average Depth (M)	Average Diameter (M)	Pumping Rate (L/S)	Cost per Cubic Meter ($)	Average Well Cost ($)
Morocco	23	34.74	1.97	34.29	461	48,815
Tunisia (CTDA/IRR)	23	21.64	3.00	3-5*	30	4,494
Tunisia (CTDA/POT)	14	23.93	3.00	1.2	73.88	15,521 12,486**

* 6-8 hours per day
** based on four Sbeitla wells

1. The water at the site was discovered by a seismic shot hole drilled for petroleum exploration. It was reported by M. Khalfi that the original six-inch diameter hole required no more than 10 minutes to drill to a depth of 24 meters. It is likely that it requried somewhat longer to drill to 24 meters but certainly not longer than one hour.

2. The depth to water in the hole was about six meters and the water was of good quality. Other shot holes in the area encountered more saline water, according to M. Khalfi.

3. The well was being deepened utilizing a home-made combination percussion-jetting drill bit. Water for the jetting operation came from the nearby irrigation canal. The bit was reportedly designed by a neighbor who had spent some time in Libya.

4. CTDA was cooperating with Mr. Khalfi to the extent of lending him a tripod with a chain hoist for removing cuttings from the excavation.

5. M. Khalfi was obviously highly motivated as compared with those responsible for the Bir Mfahdhia construction by the CTDA potable water project.

An old hand-dug well along a dirt track at Bir Mfahdhia west of Rohia was apparently used by the French many years ago. The French, it is reported by three generations of men who live at the well site, paid the grandfather of the oldest clan member to dig the well so they might have fresh water on their journey along the track. The original well constructed about 1921 was 28 meters deep. About 1950, the well collapsed and to this date has not been repaired. The people living at the well site number about 50 individuals in a small compound.

They apparently found it easier to walk four or five miles daily than to dig a new well at the site which was known to contain fresh water. The CTDA determined to pay for the construction of a new well at this site. The well is presently under construction but when visited there was no evidence of work in progress. It appears that the contractor has several sites under construction. He works at the site with the most vocal inhabitants.

It is likely, however, that M. Khalfi, although dwelling in a well irrigated and watered area, will have water from the low cost fruits of his own labors before the 50 individuals at the very dry Hamaima site will have water from their well.

Based upon the foregoing analysis of time and cost of drilled and dug well some general conclusions may be drawn.

Drilled water wells generally cost in excess of $50,000 per well for yields as high as say 60 litres per second, whereas dug wells in Tunisia at a cost of $70 to $150 per meter may cost a maximum of $4,500 per well for a 30 meter well. The evaluation team has been unable to determine the maximum yield of hand-dug wells for they are apparently not test pumped by DRES, or if they were test pumped, the data was not located. However, the evaluation team was fortunate to locate an old hand-dug well constructed by a French farmer located at Ain Essine, near le Krib. This well produces 9,000 litres of water every one and one-half hours, according to M. Ftouhi Jed Hedi, Director of the local cal cooperative. This is equivalent to a continuous pumping rate on a 24-hour basis of 1.66 litres per second. The well produces sufficient water to meet the needs of 7,200 people at 20 litres per person provided surface storage is available to store water pumped during the

night. This is a substantial number of rural people. Studies done for the location of the Henchir Bgar deep well indicated only 2,400 people within four kilometers of the well.

It seems, therefore, that if water is available within 30 meters of the surface that hand-dug wells are more cost effective in acquiring potable water supplies. It is doubtful that drilling deep wells will be more rapid than constructing hand-dug wells provided proprietors carry out the work themselves or additional contractors can be found. Actual drilling and construction time for wells drilled by the TH-60 averages about 30 days. However, other vicissitudes of life cause the well drilling process to extend to 40 days and more per well. It is likely that with sufficient well diggers and equipment, a satisfactory dug well to serve the nearby population can be built. Certainly on cost estimates alone at least 10 hand-dug wells could be constructed for each drilled well. Furthermore, the dug well approach would result in payments to more people for work and materials than payments to more people for work and materials than payments to RSH, a government entity with relatively few employees by comparision.

(b) WATER WELL DRILLING PRACTICES

1. Comparative Information

In evaluating drilling practices in Tunisia, visits were made to RSH and DRES as well as to the drilling sites of the Blocker Energy/ Le Forage at Kairouan. Table 3 lists the sites visited.

Of the sites visited, only the Rohia, Henchir Bgar and Kairouan sites were of value in evaluating the general condition of the site.

The organization of a drilling site provides insight into the quality of the work one can expect from a crew.

Table 3. Well sites visited in Tunisia.

Site	Driller	Equipment	Activity
Khamouda II	RSH	Franks 2000	Waiting to setup
Henchir Bgar	RSH	TH-60	Laydown for repairs
Rohia	RSH	Failing Holemaster	Setting up site
Kairouan	Blocker	IDECO	Waiting on cement to set

ROHIA

The Rohia site is a 250 meter well to be drilled for the CTDA irrigation project. The rig is operable but in poor condition largely attributable to its age. The crew at the site will use five RSH-made dog houses for office and living quarters. Two mud pits of 16 cubic meters each had been constructed. One is cement lined and it is likely that this will be used for drilling water storage. The volume of material which will be drilled from the standard 12.25-inch exploration hole will be about 19 cubic meters or more than the capacity of the first mud pit. Water is hauled to the site by a tractor pulling a 1000 litre trailer-style tank. The total volume of water required by the well will be about 18,000 litres thereby requiring about 18 to 20 trips for the trailer tank. At this site, drill pipe, bits, fishing tools, and other miscellaneous equipment were found lying on the ground. The rig uses 2-7/8-inch drill pipe and the smallest drill bit seen was about nine inches in diameter. The overall impression is one of a poorly organized work site. Of particular concern is the drilling of 12.25 inch exploration holes to a depth of 250 meters with

2-7/8 drill pipe. Normally one would prefer to use larger diameter pipe to forestall the possibility of the drill pipe twisting off.

HENCHIR BGAR

The TH-60 is in the process of drilling at the Henchir Bgar II locality. The TH-60 carries with it several hundred feet of drill pipe in a rack on the rig. Drill pipe and stabilizers were found on the ground. Drilling mud is not palletized and in the event of rain the entire site will be a mess. The TH-60 was inspected. It is a virtually new rig yet it was found to be quite dirty and badly in need of maintenance. The left rear leveling jack had been creeping and the piston of the front jack was coated with gunk. All lifter bars on the upper mast had slipped from their pins. Three of them had already been welded back on their pins. Though this is a solution, it will lead to problems in the future. It is evident that there are either insufficient spare parts at the rig, or it simply is very difficult to communicate with the RHS yard in Tunis to obtain the proper parts. The drilling superintendant visits the rig every one or two days.

The rig is being used to drill a 12.25-inch reconnaisance hole using tricone bits and hole openers. The tremendous shocks transmitted to the drill mast and the hydraulic system as the 12.25-inch hole opener chatters away are slowly destroying the rig. This is no doubt the cause of the mechanical and frequent hydraulic failures encountered by the rig. The failure is caused by drilling holes in very hard rock in a way which the machine was not designed for. It is clear the rig requires an air hammer.

Drilling was proceeding with foam. If the air compressor on the rig is rated at 750 cubic feet of air per minute it will only produce about 660 cfm in Central Tunisia because of its elevation above sea

level. If 4.5-inch drill rods are used in the drilling of a 12.25-inch hole, the uphole air velocity will be about 932 feet per minute. Uphole air velocities of about 3000 feet per second are generally required. To make up for this deficiency, foam is being used and this is sill not quite effective. If a 6-inch drill bit were used with the same drill pipe the uphole air velocity would be about 7,683 feet per minute and air only or misted air would be sufficient to bring cuttings to the surface. Furthermore, the reduction of the hole from 12.25 to 6-inch would speed up the drilling time by a factor of four.

The drillers, mechanics and helpers seem eager and competent and they do take pride in the rig. To the best of their ability they seem to be caring for the rig and cannot be faulted.

The drilling crew on the TH-60 only works about eight hours per day, at the end of which time they trip out and lay down their tools. If an air hammer were used satisfactory performance could be achieved in eight-hour work days.

KAIROUAN

The well visited at Kairouan is being drilled for the future site of the General Motors plant in Tunisia. The well is being drilled by Blocker Energy Company, whose local representative in Tunisia is Le Forage with offices in Sfax. The price of the well was negotiated by Blocker with their client but the well has been under the technical control of DRES. The rig is a large IDECO mud rotary rig and at the drill site is a large diesel-electric generating plant with fuel storage facilities. Two large mud pumps and other ancillary equipment are present. Pipe is neatly stacked on pipe racks. The mud pit system

is adequate for the project. The well has followed the standard design of a 12.25-inch hole to 400 meters.

Following completion of the hole, an electric log was run and DRES designed the completion of the well. The well was enlarged to 17.5 inches and a 9-5/8-inch casing and stainless steel Layne well screen was set. The well was bid at about 400 TD per meter. The cost of the well per meter of material removed was $3,643. The operation was under the supervision of an American and a Canadian driller. The work site was highly organized, clean and well-maintained. Finally and most importantly, drilling proceeded 24 hours per day. The well was spudded at noon on September 1, 1983 and was finished by September 15, 1983.

At the Kairouan site, the drillers earn high wages and are on 28-day flip-flop assignments: they work 28 days and go home for 28 days.

In general, then, the RHS drill sites are not well organized because of maintenance and supply problems. Because they only work eight hours per day, the RSH wells require an inordinate amount of time to complete even though their costs are in line with world-wide costs for similar wells.

CONCLUSION

All well construction in Tunisia seems to be under the operational control of DRES. It is either their policy or simply customary practice to drill a 12.25-inch pilot reconnaissance hole to total depth before it is electrically logged. After logging, it is again practice or policy to open the hole to either 15 or 17 inches in diameter and case the well with 9-5/8-inch steel casing followed by installation of a gravel pack. If the well is less than 200 meters deep the so-called California method of construction is used. If it is deeper than 200

meters, the so-called Layne method of construction is used. The California method utilizes a single string of casing and screen. The Layne method telescopes screen through the casing to the bottom of the well. No variations from this method were found.

The method may stem from the general expense of drilling and the need for large amounts of water from a successful well. If so then any useful well would have to have 9-5/8-inch casing and consequently the GOT purchased a very large supply of this pipe. These wells, however, were not envisaged for the project.

The consultants retained by AID have stressed the need for intermediate wells; however, the wells being drilled with the TH-60 are to the same specifications for large wells.

Finally, DRES officials stress that 12.25-inch reconnaissance holes are only drilled in areas of known hydrology. Yet the Henchir Bgar wells were drilled to 12.25 inches as reconnaissance wells in an area where only three other wells exist. The Henchir Bgar I was declared a dry hole by DRES. A 6-inch reconnaissance hole would have been more advisable.

2. Drilling Capabilities of the TH-60

The TH-60 is a sohpisticated and versatile rig. The rig is designed for drilling 6-inch cased wells to depths as great as 500 meters in most terrain. Shale, clay and poorly indurated sandstone may be drilled with tricone bits. Tungsten carbide or diamond bits may be used on harder formations. However, the TH-60 is particularly designed to use an air hammer on hard formations rather than tricone bits of any type or diamond bits. If larger holes are sought a TH-4 is a more

appropriate rig. Any hole larger than an 8-inch drilled hole is not advised without additional air capacity to maintain high up-hole air velocities.

The single most important factor in determining the size of hole which may be drilled with the TH-60 is up-hole air velocity. Air velocity is governed by compressor volume and the area of the annular space between the drill rod and the bore face.

Though the compressor on the TH-60 in Tunisia is rated at 750 cfm, because of the elevation at which it is operated it is likely that it only produces less than 660 cfm.

For effective cutting removal up-hole air velocities must be maintained at about 3000 fpm, and uphole mud velocities should never be less than 70 feet per minute and should normally be about 150 feet per minute. Therefore, if 4.5-inch drill rods are used in an 8-inch hole the up-hole velocity of air will be about 2800 fpm and the up-hole mud velocity will be 77 feet per minute. On air some foam will be required. A 10-inch hole using 4.5-inch drill rods is asking for trouble particularly if crevices and fissures occur which will drain air or mud away from the bore holes. If a 6-inch hole is being opened to 10-inches the problems may not be as great because a smaller amount of material is being removed than would be removed if a 10-inch hole were drilled in a single pass. A 10-inch hole will have an up-hole velocity of only 1517 fpm.

As drilling conditions become more complex the practical depth to which a straight hole can be drilled decreases. Therefore, in areas of hard crystalline limestone and siliceous sandstone the effective depth of the TH-60 probably should not exceed 200 to 300 meters.

To further gauge the ability of the TH-60 equipment, upon completion of the team assignment in Tunisia one of the team (Turner) contracted on behalf of a client for the construction of a 6-inch cased well 200 meters deep on the Colorado Plateau of northern New Mexico in the United States. The hole was drilled by a TH-60 using an air hammer. The rock drilled consisted of interbedded shale and hard fractured sandstone. Total drilling time was about six hours. Another hole 35 meters deep was drilled between noon and four o'clock the next day.

The only difficulty encountered was the presence of small fractures into which cuttings find their way. If air was cut off, the cuttings tend to fall back into the hole on top of the air hammer. If large cavities were present, this problem might result in the loss of the air hammer and drill pipe. This is not expected to be a problem in Tunisia.

3. HAND DUG WELLS, DRILLED WELLS, AND SPRINGS

(a). Dug wells and drilled wells

From the foregoing analysis it is clear that:

1. Hand-dug wells are less costly than drilled wells and even with small yields of one to two litres per second, they are capable of supporting large numbers of people.

2. Reconnaissance pilot holes of 12.25 inches in diameter are not necessary for evaluating the yield of a normal well and are not intended to be drilled by the TH-60.

3. RSH drilling sites are not well organized.

4. Some large private rigs are available in Tunisia for drilling and constructing deep wells in a timely manner.

If the goal of the project is to locate low yield wells, the drilling of deep large diameter wells by the TH-60 should be abandoned. The TH-60 should be used to locate water supplies for hand-dug wells. In this mode of operation the rig would carry perhaps only 30 meters of 4.5-inch drill pipe and it would drill 6-inch holes to a depth of 30 meters. The TH-60 should not require more than one or two hours per hole in the actual drilling time. Given the working habits of Tunisian crews, a crew could assess about one or two locations per day. If hard bedrock is encountered before water, the hole should stop.

Sites identified as having shallow ground water would be developed by means of dug wells, either by the CTDA itself through contractors or through a self-help project. Certainly, information obtained during field trips suggests that self-help financing leads to dug wells at about one-third the cost. In operation it is envisaged that a CTDA survey team will canvas an area to determine who wants a well and is willing either to do the work themselves or to take out a loan to pay to have a contractor do the work. Alternatively a rural water-users' association with specified responsibilities under law, may be established.

Individuals or communities that respond positively would be visited by the TH-60 which would proceed to drill a shallow test well. If at least three meters of saturated shallow ground water are encountered, the individuals or community would be granted financing or equipment assistance for either the self-help program or to engage a contractor. If a dug well cannot be constructed at the site, the rig may drill deeper and a cased well may be constructed.

Rural electrification has progressed to a significant state in the rural areas visited and insofar as possible, the well site should be located near electrical power.

Because of poor pump maintenance, it is probably inadvisable to create numerous low yield mechanized drilled wells.

(b) Dug wells and springs

The average cost of a dug well plus the attendant civil works for dug wells constructed by the potable water program CTDA is $10,318, or $431 per meter depth for the average well of 23.93 meters. The average cost of a dug well financed by the CTDA irrigation program is $4,494. Therefore, the civil works for spring development should not cost more than $5,824. This is slightly more than the cost of a dug well alone and on the basis of water availability alone, the dug well is much more cost effective. A dug well may provide 1.5 litres per second whereas a spring system may only provide 3 litres per minute. At 1.5 litres per second, the cost of a dug well per beneficiary is $.69. At 3 litres per minute, the cost of the spring system per beneficiary will be $26.96. This analysis is based upon a rural water use of 20 litres per person per day.

Private dug wells may be constructed for only 50 TD per meter or $1,687 for the average depth well. In this case, the cost per beneficiary, based upon 1.5 litres per second will drop to $0.26 per beneficiary. This is even less than the cost per beneficiary of drilled high capacity wells. The cost is probably less than the actual cost per beneficiary for drilled wells because there is significantly more water produced by the drilled wells than there is population to consume it.

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It may be concluded here that spring systems and drilled wells should be used as a last resort. In order of cost per beneficiary, dug wells should receive top priority followed closely by spring development and then trailing some distance behind, deep wells.

(c) Improvement of Operation to Reduce Construction Time

One of the most time-consuming operations in the construction of wells is the time to set up and prepare a site. Very little site work will be required if an air hammer is used and holes of proper size are drilled. Drilling time will be so rapid that living quarters at a site will be unnecessary. Downtime is mainly caused by construction of large diameter holes using tricone bits; a use for which the rig was not designed that leads to frequent rig failure. Rig failure leads to a need for spare parts which may or may not exist at all in the country. Down time is also caused by lack of a regular in shop cleaning and maintenance program. The need for advice from the roving drilling superintendent who may not appear for several days also causes down time.

Two-way single side band radios will improve communications between widely separated field crews, drilling superintendants and central stores. Increased experience on the part of drilling crews should reduce the amount of guidance required from the drilling superintendent if the drillers will assume the responsibility of their decisions.

If the rig is used as it was intended and regularly maintained, there should be few repairs necessary. Ingersoll Rand, because of extensive use of TH-60 rigs, knows which parts are most frequently

needed and these should be kept in stock in Kasserine. Ingersoll Rand maintenance information for the TH-60 and truck are supplied in Attachment 1.

Drillers will only have to work eight hours per day or less to complete drilling wells quickly if the equipment is used as intended. It was never intended to drill 12.25-inch holes with tricone bits. It is recommended that all exploratory holes be 6-inches om diameter and be drilled on air or air and mist only.

After encountering water or reaching total depth a one-hour bailer test or an injection test should be conducted followed by measurement of recovery or pressure fall off for a period of two hours. This data will enable determination of undamaged aquifer transmissivity from which production well yield may be calculated.

If DRES determines that the hole will produce water, the electrical log should be run to determine screen settings and drill cuttings should be examined to determine screen slot openings.

If 4.5-inch drill rods are used, the bore hole may be opened to 10 inches in diameter using a hole opener on the air hammer. Depending on the size of the bore hole, the hole may be cased with either 6, 8, or 9-5/8-inch casing. No gravel pack should be required in the hard formations present in Central Tunisia. Even in the case of unconsolidated formations, natural gravel or sand packs can be developed if proper screens are used.

RSH personnel indicate that it is not possible to drill a 6-inch hole because the drill collars are 6-inches or slightly larger. Using an air hammer, drill collars will not be necessary. The hammer is designed to operate under its own weight and with the weight of

the drill rods. In fact, the "Hold Back" lever on the control console is used to remove weight from the hammer when necessary.

Use of an air hammer is recommended also in soft-to-medium-hard formations. Because the TH-60 is not equipped with a casing hammer it will be difficult to use the hammer in unconsolidated rock formations and mud rotary methods will be preferred. The acquisition of an air hammer will present some new problems. It is not uncommon for buttons peripheral to the bit to wear off. If only one wears off, the bit must not be used because it will tend to drill a crooked hole. Also, it is common for the buttons to wear somewhat unevenly. The bit drills best when the buttons are truly hemispherical in shape. Therefore, it will be necessary to purchase a button grinder and gauge to dress the buttons periodically. It is recommended that Ingersoll Rand provide a driller experienced in air hammer methods. Failing that IDA will endeaver to provide such a person if requested.

(d) Pumping Equipment

The question of what type of pump should be installed in wells drilled and constructed under the present program seems to be undecided. Basically, several types of mechanical pumping methods exist. Dickson et al. discussed many in detail, including electrosubmersible pumps, line shaft turbine pumps powered by either a surface electric or diesel motor and air lift pumping. The pros and cons of each of these methods will be discussed in turn.

1. ELECTROSUBMERSIBLE PUMPS

Electrosubmersible pumps are convenient, out of harm's way down in the well and extremely reliable provided they are powered by uniform electrical current and provided they are not subject to widely

varying pumping conditions. For best results, electrosubmersibles should be installed in sealed wells, should have a constant regulated power source and should pump at a discharge rate which is near the peak of efficiency on its performance curve. It was noted that suppliers of electrosubmersible pumps do provide pump performance curves with their bids.

The major problem with electrosubmersible pumps in rural areas is the provision of a reliable source of electricity. In areas where rural electrification has taken place this is not a problem. In other areas it will be necessary to depend upon an electrical generator. Some diesel-powered generator sets when maintained and operated properly can provide uninterrupted power for years. The author is personally aware of an electrical generator powered by a German Witte diesel that has been in continuous operation for more than 35 years. It only requires a biweekly change of oil. Unfortunately, Witte diesels are no longer manufactured. Carefully rebuilt Blackstone diesels are a good substitute. The major problem then with diesel-powered generator sets are: necessity of an operator/guardian to look after the equipment and ensure its proper operation, and the necessity of having diesel fuel available. The salary for the operator/guardian and the cost of fuel are continuing operating costs.

A more modern approach to the operation of electrosubmersible pumps which is relatively maintenance free and which does not require diesel fuel is the use of solar power. Solar powered electrosubmersible units are now becoming widespread throughout rural Africa. The only exposed part of the system are the solar panels and the DC to AC

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power inverter. These items could of course be subject to destruction as were the AID and CARE handpumps. However, the primary reason for the destruction of the handpumps may have been that family groups were not able to have their own private tap and that the waiting time to fill water containers was interminable. A water-users' association may have provided a solution to this problem.

The main drawbacks to the solar-powered installation are cost and nonfunctioning on cloudy days. Solar powered pumps require no maintenance other than normal and they can be made to operate at night by using batteries to store electricity when the pump is not operating. A 35 panel system capable of producing about 8.5 gpm in June, in Tunisia, from a depth of 250 feet, retails in the United States for about $17,500. Solar powered electric pumps that will pump one litre per second from about 80 meters are also available. These pumps may also be suitable for dug wells.

2. LINE-SHAFT TURBINES

Line-shaft turbine pumps are vertically disposed centrifugal pumps installed in a well. They may run for many years without service. The line-shaft turbine is powered by motors on the surface which can be serviced easily.

The power plants are either diesel or electric motors. In the case of diesel power plants, they are connected to the line-shaft turbine through a right angle drive unit atop the well. The power plant usually has a clutch so that the pump may be engaged slowly and so that the power plant may be disengaged rapidly after it is shut off. The disengagement is required because unlike electrosub-

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mersible pumps, line-shaft turbine pumps do not have check valves which prevent water in the discharge pipe from running back into the well. As water runs down the discharge pipe, the shaft turns rapidly backwards.

Several problems tend to develop with the line-shaft turbine itself. When first installed and periodically thereafter, the clearance between the impeller blades and the interior wall of the impeller blade housing must be adjusted. If not adjusted properly, the impeller blades will rub against the housing. This results eventually either in rupture of the housing or significant wear on the impeller blades such that pump efficiency plummets.

Another problem is the tendency of untrained people to release the clutch too rapidly when engaging the power plant to the line-shaft. This commonly leads to torqueing off the line-shaft. That is, when the shaft is engaged it will shorten and may pull the impeller into the housing. If it jams, the shaft twists off.

Finally, the pump cannot be effectively set at depths of more than 200 meters, since even if it properly engaged, the line-shaft will torque up. To compensate for this, the clearance of the impeller blades and the housing must be greater leading to greatly reduced pump efficiency.

The electrical motor drives are certainly the most efficient but they require a source of electrical power just as the electrosubmersible does.

In all cases, the line-shaft turbine pump will require a significant amount of maintenance and adjustment. Finally, if a diesel power plant is used, it will require fuel, the acquisition and transport of which pose their own problems.

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Line-shaft turbines are not recommended.

Air-lift pumping is popular in some extremely out of the way places such as the town of Nara in the Malian Sahel. Here, the French constructed a deep six-inch well and inserted in it an air-lift pumping device consisting of an air injection and an eductor pipe. A diesel motor drives an air compressor. Water is air-liftted into a large capacity water truck by which the water is then distributed to the community. The drawback to this system is the need to transport fuel about 750 miles from Abidjan.

The advantage to air-lift pumping is that there are no mechanical devices in the well. The only moving parts are on the surface.

Air-lift pumping is a rather inefficient way of pumping water but rates as high as 3 l/s have been achieved by the author on a continuous basis in the performance of pump tests. Information on calculation of air volumes necessary to achieve specific pumping rates is given in Attachment 2.

The primary drawback to the air-lift method is that the compressor again uses diesel fuel and will require an operator/guardian trained in its service and who will be responsible for acquisition and transport of diesel fuel.

4. OTHER METHODS

Other methods of pumping exist. These include windmills, hand-pumps, and bailers. Each method works in some parts of the world. In Mali hundreds of windmills installed by the French Assistance Program do not operate, whereas in the United States and Australia windmills do function. In Ecuador and to some extent in the Dominican Republic

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and Tunisia, hundreds of handpumps which were installed under various programs no longer function. The author notes with some interest the efforts of funding agencies to reinstall handpumps in the Santa Elena Peninsula of Ecuador where a previous program carried out by a local regional agency failed completely. Bailers are highly successful in the Amazon basin, Ecuador, Tunisia and elsewhere. In Tunisia, draft animals are used to withdraw the bailers and the contained water from the wells. One such operation was seen at Rakhmat.

(e) Different Interventions: Spring Development

We have already compared drilled wells with dug wells, so these comments will concentrate on spring development.

Several spring sites developed by the CTDA project as well as the El Kesra Spring were visited during this evaluation. These are listed below in Table 4.

Table 4. List of springs visited in Central Tunisia

Spring Name	Type of Spring	Discharge Rate
Hababsa Oued	Base flow from wadi	Not flowing
Hajrat Ettir	Sandstone reservoir	Not measurable
Ain Smiria	Base flow from wadi	Approx. 3 litres/min.
Tounzar	Base flow from wadi	3 litres/min.
El Kesra	Limestone reservoir	Approx. 60 litres/min.

The first four springs visited were the subject of an intervention by the CTDA. All had a spring box in the respective wadi from which the water is led to a public fountain.

At the Hababsa Oued spring, water was led to a circular open air storage tank from which water was supposed to flow to the public fountain and animal water trough. Excess water was sought by local residents for irrigation. In actual fact, no water was observed flowing into the public fountain or animal trough. Most of the water was running off for irrigation. The civil works had not been constructed according to plan and didn't work.

At the Ain Smiria Spring, there were three small seeps observed in a bifurcating wadi. Only one of them had been diverted to the public fountain and animal trough.

The major problem with this spring was that two local people decided to use the excess water for irrigation and they constructed a rather large canal to lead the water to their fields. This plan would have been successful if the elevation of their fields were lower than the elevation of the animal trough. The spring and the field are at the same elevation and the water in the canal does not flow resulting in a vast pool of stinking stagnant water which makes the animal trough unuseable. At this site, the excess water must be diverted back to the wadi.

At Tounzar, the spring and civil works were working well. It is reported that the measured flow of about three litres per minutes sustains the water needs of about 800 people in the immediate vicinity. If this is true then the average water use for these people is about 5.4 litres per day at the end of summer.

The spring at Hajrat Ettir is different than the other springs visited. This spring rises from gravity drainage of indurated Miocene

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dune sands which overlie flat-lying black shales. The shale and sandstone beds were deposited within the core of a breached anticline. The spring box has been placed at the spring and the water is led by pipe to a small concrete reservoir about 100 feet lower in elevation. A one-inch brass gate valve at the base of the reservoir controls the flow of the water into the public fountain and animal trough. When visited, the brass valve was missing and its handle and the valve threads had been stripped. In essence, the system was not functioning and in fact had been purposefully damaged.

Springs for development in Central Tunisia are, therefore, of two general types. The first type of spring is associated with water flowing beneath the alluvium surface in the wadis. The second type is associated with ground water which is perched in a geological rock unit. Where the ground-water table intersects the land surface, the water flows out as a spring, as at Kasra and Hajrat Ettir.

It is evident from the visits made to CTDA spring-development projects that standards of operation set by the CTDA may not be the same standard of operation followed by the beneficiaries of the project. There always seems to be a desire on the part of someone to utilize excess water for irrigation. This is a reasonable use for excess water. Also, there always seems to be a desire for water unrestricted by valves and taps of any type despite the fact that the valves and taps may allow storage which will be to the benefit of more people. They may believe that the destruction of valves and taps will allow the water to flow faster. One may try to force the

standard upon the beneficiaries by using "heavy duty" valves or as a final resort a guardian to police the facilities.

One technical solution to the problems would be to use heavy-duty cast iron from glove valves. These valves are commonly used in the oil and gas industry in shutting in cement jobs and will withstand abuse. They are rather inexpensive costing only about $30 each. Certainly any brass valves or taps are not durable because of the softness of brass.

Another problem with most of the springs visited is that the dimensions of the animal trough are so large that given the low flow rate of the water, there is insufficient velocity to remove dirt which finds its way into the trough.

Finally, because of the variation in the types of spring system and the variation in their topographic and geologic settings it is not possible to design standard plans for civil works necessary to develop each potential site. Therefore, the design and costing for each site is more time consuming. In general, the magnitude of civil works at a spring site will not be more expensive than the civil works at a dug well site. The cost to construct the spring box and lead the water to the reservoir or public fountain should be less than a dug well and should not require as much time. The only drawback to the spring systems developed by CTDA seems to be the flow rate of the spring which may be much less than the flow rate which could be expected from a hand-dug well.

(f) Socio-Economic Factors

1. WATER-USERS' ASSOCIATIONS AND SITE SELECTION

Under what conditions and to what extent should rural people pay

all or part of the cost of systems to distribute potable water? There are those who want water and are happy to pay a fee for easy access to it and there are those who will pay nothing. At the Rakhmat dug-well men and women require up to eight hours to fill 500 litre animal-drawn mobile tanks. A new tank cart costs at least 180 Dinars. If water were within easy reach of individuals or groups, they might be willing to pay at least 180 TD per family for a dug-well. Because manufacturers of mobile tanks don't extend credit, CTDA should not either.

CTDA should inquire of individuals or groups of individuals if they will pay for a drilled well and the type of pumping plant they wish. This is a marketing activity. If there are those who do not wish water, they may be passed over. This method of site selection removes the complicated political process of site selection from the picture. This method is effective in the Amazon Basin.

If there are no individuals or groups of individuals willing to ay for a well, no well should be installed unless a responsible users' group is established under law.

Water-users' associations are of ancient origin, and because they were created out of the need for a common effort to exploit water resources, they have existed de facto in many places before they were recognized by law. In Argentina, as soon as there is a common source of water, an association is formed ipso jure. There is no necessity to vote any constitution or by-laws, because the law provides for the details of organization of the association. The characteristic feature of this type of organization is that it cannot be dissolved other than by a total cessation of water use from a particular source.

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In Tunisia, there are laws after which community water association laws should probably be drafted. In particular is Act. No. 63-18 of 1963 in which Article 22 provides that landowners in public irrigation zones may be compelled by decision of the Secretary of State for Agriculture to join compulsory agricultural water groups. This same authority should probably be extended to rural water supply projects in Tunisia.

A rural water-users' association understands the needs of rural water systems. It helps these systems by providing representation, consultation, and training for operators and users. Field workshops are conducted to meet specific needs of people for information. These sessions may be management oriented, operational, regulatory, legislative, or financial in character.

Through meetings with members and officers of the organization, valuable information and concerns are exchanged. Common water problems in one community may lead to the solution of problems in another community.

A central association representing a number of water systems provides a strong representative voice, both on a local and national level. An organization of many members carries more weight than would a small group of people organized for example about a single low yield well. With water being the most fundamental resource of man in any culture, a water-users' association can play an important role.

2. WATER RIGHTS

In Tunisia all watercourses were placed in the public domain in 1885 (Decree of September 24, 1885). Detailed regulation of their

use had to await the Decree of August 5, 1933. This Decree distinguishes between permits, which are issued for non-permanent construction works or conduits, or for the use of springs on private property which have such a small flow that they cannot be used for public purposes.

The CTDA program has an underlying premise that its projects will provide watering points which are open to the public. This is an admirable objective of government. However, inasmuch as it has been shown that the most cost effective method of providing potable water to rural areas is through the use of dug wells, and inasmuch as a self help program of well construction is a desirable method of financing well construction, it should be accepted that

1. Individuals and groups of people may construct wells through their own efforts with no financing from the government.

2. Individuals and groups of people may seek government financial help for the construction of dug wells.

3. Those who dig their own wells or those who seek financial assistance and are responsible for repaying the loans may not wish to share their water with others who have not contributed and may not have the same pride of ownership.

It should be accepted that private wells financed by CTDA may not be available to all potential users of water in an area. And those who have constructed wells at their own initiative and those who have financed the construction of wells must be allowed the usufructuary right to water. This right is not a right to the water itself but only the right to take the water. All rights to the water remain vested in

the government. The principle embodied by the usufruct is that the beneficial use of water shall be the basis of the measure and the limit to the right to use water. As a result, those who through their own labors or through financing for which they are at risk must be allowed to charge a fair amount for water taken from their well. If there are those who cannot pay, they may continue their walk to water or may wish to construct their own well if water is available. If water is not available in a locality, the government may wish to intervene but only if a water-users' association has been formed. However, the availability of shallow ground water has not yet been established sufficiently well to derive planning decisions.

3. EXCESSIVE WATER USAGE

There may arise arguments to the effect that large numbers of dug wells will deplete the ground-water resources of an area. To this concern several responses are in order.

1. Deep high-yield wells serving many people will deplete the water resources just as fast as numerous shallow wells over a wide area. In fact, the impact of a single large capacity well on the ground-water table will be greater in the vicinity of the well than the effect of numerous widely dispersed wells.

2. The ground-water resources within the project area are totally unknown in a quantitative sense. Furthermore, in any quantitative study, the degree of uncertainty in making the ground-water resource calculation will probably be more than the total amount of water which would be consumed by the rural peoples. The degree of error in making calculations of ground-water resources is commonly plus or minus 30%.

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3. Finally, one school of thought holds that if you allow people to develop whatever ground-water resources are available to them their level of economic achievement will rise sufficiently to enable them to seek alternative, more costly sources of water.

A shining example of this philosophy is the State of California in the United States. The southern water-short area of California became the industrial area of greatest importance to the economy of the state. As water resources became insufficient, southern California began to look at importation of water from northern California. These projects are today a reality. In fact, there are plans for bringing water into California, Arizona, and New Mexico from the Yukon River in Alaska.

4. CONTRACTOR AVAILABILITY

The CTDA in order to implement its various interventions has contracted with third parties. In the case of the drilled wells, they have contracted with the RSH. In the case of dug wells and spring development, they have contracted with three contracting firms and a fourth is soon to be approved. Of the firms interviewed, only two were responsible for spring development and the digging of wells. The third contractor was only responsible for the construction of civil works at the various sites.

Of the two remaining contractors, M---- seemed clearly the most experienced in terms of the dug wells although this activity was by no means his only capability. M---- dug his first well in 1952 and has since then completed about 150 dug wells. He has completed 12 wells for the CTDA project and three are presently under construction. Of all the wells he has dug which range in depth from 15 to 50 meters, he estimates that only one to two percent have been dry. These wells

wells are dispersed over three governorates in central Tunisia. Crews working for M---- consist of about seven men with two to three men in the well. The crews work eight hour days and are commonly able to penetrate about one meter per day.

When the water table is reached, a liner is set which contains downward slanting holes. These holes are sealed temporarily and the well deepening process continues. A pump in the well removes any water. Using this method, M---- is able to penetrate several meters below the water table until the inflow from the bottom of the well becomes greater than the capacity of the pump.

X---- on the other hand seems to be primarily engaged in the development of springs. He constructed the Ain Smiria and the Hajfrat Ettir spring box and civil works. He also is involved in the construction of dug wells. He is the contractor at an unfinished well at Hamaima discussed earlier. X---- dug his first well in 1962 for himself. Since then he has dug eight wells including two for the CTDA project. X---- also says that he made a chain of wells at Bou Dries.

In the construction of wells and springs both contractors indicate that they operate from the same plans for all wells and springs. X---- clearly has the more difficult job in the development of the springs and at the same time he has the least experience and, for projects which he has not constructed according to plan, he has not been paid. Furthermore, he apparently was the only bidder on several projects and he bid an unrealistically low price. It is significant that he bid at all and it reveals an individual who is willing to work hard and who has a desire to learn. Though he has certain educational handicaps, education has never been a prerequisite for success. In the

case of X---- it is suggested that CTDA work with him to encourage development of construction skills and pay him a fair price for the work (regardless of his bid).

In the case of M---- it is evident that he is a highly experienced contractor who is capable of making responsible bids and executing the projects well.

One significant problem for the contractors is the fact that so many of the sites are located at very distant places and it is not possible for one supervisor to supervise more than one or two projects. Consequently, costs will be higher for remote project sites. Note that these same problems do not necessarily occur if CTDA has simply financed a private dug well or if an individual simply undertakes to construct a well himself with possibly some equipment from the CTDA project.

A further observation made by the contractors was that the people seem happier with government wells than with private wells owned by others because water from the government wells is free. This certainly is the case at Hammam Kesra. Here though SONEDE has provided private taps to homes, local residents prefer to use the old CARE-Medico well for wash water. This well is concrete lined and about 10 meters deep. The water in the well was observed to have all kinds of floating garbage. The well has an animal trough and had a pump which is now gone.

5. SUGGESTIONS FOR IMPROVING CONTRACTOR PERFORMANCE

Discussions with the three contractors working on the CTDA sites suggest that two of them are already extremely competent contractors and it is hard to imagine methods for improving their skills given the

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technology they are required to work with. X---- on the other hand seems to lack certain practical skills such as planning for multi-purpose gravity flow water distribution systems for which knowledge of the elevation of water source and delivery points is necessary. This is not to say that he is not skilled in the work that he is doing. Given proper supervision from the CTDA office X---- can do good work and can in fact learn from his experience. He certainly seems to have the will to learn.

6. FACILITY DESIGN

The designs for the civil works and in many cases the actual constructions have been approved by USAID. Nevertheless, the design of the civil works at each water development site seems to leave something to be desired. The public watering taps and animal troughs are usually a public nuisance. At all sites visited save one, water had flowed off of the concrete apron surrounding the public tap and animal trough. This is due to several factors.

1. The concrete pad is level or slopes away from the animal trough and public fountain.

2. Individuals using hoses pipe the water away from the faucet at the public fountain to large containers either in wheelbarrows, on animals or constructed on a carriage. The containers are commonly washed down before being filled. This wash water and the overflow from the containers muddies the ground.

Animal troughs are always a problem because the water does not flow at sufficient velocity to keep dirt and sludge from accumulating in the troughs.

The only facility which was seen which was clean and orderly was behind the school in Hamaima. This facility is a CARE-Medico facility in which a line-shaft turbine pump obtains water from a shallow dug well. The well is operated twice daily by an on-site operator who is paid 45 TD per month. Water is stored in a storage tank and is discharged into a public fountain and water trough. The concrete apron around the public fountain contains a drainage canal which leads the water away from the site. The animal trough is separated some distance to the west of the public fountain. The operator does not permit water to be slopped around the site. The operator seems to take great pride in his work and the responsibilities it carries.

Properly designed and constructed concrete aprons which allow for water catchment and controlled drainage would improve conditions around sites. A small dry well at each site would receive the drainage water. The dry wells are circular pits about 0.5 meters in diameter and about 1.5 meters deep. They are lined with clay bricks and capped with circular concrete slab. Drainage water is led into the dry well through clay or PVC pipe. Drains may be provided for both the animal trough and the public fountain.

At several of the springs visited, water was allowed to flow continuously from an open pipe. This standard of design is probably acceptable to the people of the area. Because many of the springs are in wadis, there is no elevation drop which will allow the water to be stored in a reservoir.

For those public fountains which do have faucets and other types of valves, heavy-duty cast-iron ball valves may be more durable.

7. MAINTENANCE

Water should be withdrawn from dug wells by some mechanical means either utilizing an electric motor and centrifugal pump set on a platform in the well within 15 feet of the water table, a line-shaft turbine powered by a surface power plant or air-lift pumping. The well should be capped to prevent garbage and debris from contaminating the water. Water may be withdrawn by buckets or draft animal-powered bailing devices.

Any mechanical equipment will require an operator to maintain it. Operators must be trained in the care of the mechanical equipment. They must be trained to: keep the equipment clean, change oil, lubricate moving parts, tighten nuts and bolts occasionally and most importantly, they must be trained to maintain the sealed integrity of the well. It is of little consequence that newts and salamanders and other small insects may live in the well itself for these pose little health hazard. The operator must police the well and facilities to ensure proper use by people and to ensure that unsanitary conditions are not created. It is likely that the experience in maintaining and caring for a well could be passed on within a family. These individuals may be trained to read and report water-meter readings, water-level readings, and other information of statistical importance. The operator may be an employee of a water-users' association.

(b). SPRINGS

Springs flow by themselves. There is no significant effort required to maintain a spring except a periodic cleaning of all the internal parts of the facilities. If the civil works at a spring contain valves or other moving parts, a maintenance supervisor must ensure

that these components work properly. He should make sure that valves or faucets are always closed when not in use to prevent waste. However, if the standard set by the beneficiaries is that the water should flow all of the time, the maintenance supervisor may earn the enmity of his neighbors and decide that their friendship is more valuable than the spring.

The maintenance supervisor of a spring should attempt to achieve the same high standards of cleanliness at the public fountain and animal troughs as demanded at the dug well sites.

(c). DEEP (DRILLED) WELLS

Mechanical equipment must be kept properly lubricated. In the case of the line-shaft turbine pump, oil must be regularly applied to the line shafts. Oil must not be applied to line shafts in excess which could result in oil entering the well and floating on the water table. If diesel engines are used, oil must be periodically changed. Equipment must be kept clean and the pump house must be kept clean. The wells must be adequately sealed to prevent surface contamination from falling into the well.

Operators have been found at Hamaima and at the irrigation well at Ain El Khamisia. These individuals guard their wells and were found to be competent operators. In the case of the Ain El Khamisia well which has been in operation for about 15 years, the operator seems to have achieved an important status in his community. The maintenance-operators must be trained in the adjustment of the line shaft if line-shaft turbines are used. They should be trained to read water meters and to measure water levels in the pumping well utilizing the air-line method.

It is clear from a visit to the well at Henchir Ali Majnoun that at least the diesel power plant is being poorly maintained. Examination of the engine in operation revealed the following:

1. Two of the 12 nuts which fasten the exhaust manifold to the engine were missing:

2. Five of the 12 bolts were completely unscrewed waiting to fall off;

3. The cranckcase was only half full of oil; and,

4. The four circular seals on the bottom of the engine which are fastened to the engine block by five hexbolts each were loose. One bolt had worked its way completely out and lay on the floor beneath the engine and crankcase oil was leaking out.

This engine will shortly destroy itself. The operator of the well has no engine oil on hand. He also has no proper tool to repair the engine and tighten the various nuts and bolts.

ANNEX: Wells and Springs Visited

As part of the project evaluation many of the drilled wells and dug wells and springs financed by the project were visited and inspected. Also several non-project wells were visited to determine the effectiveness of private water supply intervention. Table 5 is a list of all sites visited.

Table 5

List of Project Drilled Wells, Dug Wells and Springs Visited within Central Tunisia

Name of Source	Type	Owner	Yield	Remarks
Ras El Oued	Drilled	CDTA	5 L/s	Poorly maintained
Sidi Ali Majnoun	Drilled	CDTA	43 L/s	
Henchir Bgar I	Drilled	CDTA	nil	Contained water
Khamouda II	Drilled	CDTA		
Ain Ezzine Krib	Dug	Co-op	1.5 L/s	Dug by French
Hamaima	Dug	CARE	1.5+L/s	Well operated
Oued La Biadh	Spring	CDTA		Wasn't operating
Hamaima	Dug	CDTA		Not completed
Rohia	Drilled	CDTA/irr		Work just begun
Shiba	Drilled	SONEDE Ag Dept	100 L/s 32 L/s	About 15 years old Several years old
Lahbel/Sbiba	Dug	Mahamed Labid Khalfi		Digging in progress
Ain El Hamisiah	Drilled	Ag Dept	60 L/s	15-year old well
Ain Smairia	Spring	CDTA	3 L/m?	Stinking mess
Znadia	Chain	CR	10 L/s	Inoperable
Tounzar	Spring	CDTA	1.6 L/s	Good condition
Bir Mgazel	Dug	Private		Animal lift, 40 years old, 85m.
Zerge Baagie	Dug	Private		Uses donkey, 1st class 9 mo to dig, 57m deep
Rakhmet	Dug	CDTA	1.7 L/s	No water meter Old Roman well
Rakhmet	Dug	CDTA	1.7 L/s	15m deep, tank discharge rate: 0.2 L/s
Aitha	Dug	Lamin Suifi		25m deep, 4m diameter cost 1200 TD or 48 TD/m; 7 mo., 6 paid workers at 3.5 TD/d + 3 family mem 1 hour to pump down, 23 to recover, delegation funded engine

Table 5 (contd)

Name of Source	Type	Owner	Yield	Remarks
Bir Melech	Dug	CDTA		5+ m deep, uses triangular animal trough. Better than CDTA design. Near Oued old well..
Bir Kuwi Assiyah	Dug	CDTA		5m+ deep, near Oued
Bir Haj Sefi	Dug	GR/Priv private (IRR)	3 L/s	Yield decreased from 6 hrs continuous to 1 hr on, 1 hr off. WL declined Km 20 to Sid Rou Zid
El Amra	Dug/ drilled	Private	3 L/s	23m dug + 18m drilled by hand cable tool. Cost TD/d for 4 days to drill 18m. Yield about 31 L/s continuously. Water level dropped slightly. Km 20 to Sidi Rou Zid.
Hajret Etter	Spring	CDTA	1.5 L/s	Well developed. Gate valve broken.

Attachment 1.

RECOMMENDED LUBRICANT SOURCES

SAE 90 GEAR LUBE:	SOHIO GEAR EP 90
SAE 30 CRANKCASE OIL:	SOHIO FACTO SAE 30
PISTON COMPRESSOR OIL:	SOHIO ELDORAN A-48
SCREW COMPRESSOR OIL:	MOBIL SHC 626
GREASE	SOHIO BEARING GUARD NO. 2, ATLANTIC RICHFIELD CALDRON, EP1, ASHLAND VALVOLINE DB-2.
ROCK DRILL OIL:	SOHIO FACTOWAY 70

* * * * * * WARNING! * * * * * *

FAILURE TO COMPLY WITH THE FOLLOWING PROCEDURES MAY RESULT IN SERIOUS DAMAGE TO ANY OR ALL PARTS OF YOUR CYCLONE DRILL MACHINE!!

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 1/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED	
DAILY		
	CHECK ENGINE CRANKCASE OIL	☐
	CHECK AIR COMPRESSOR OIL (TANK OR CRANKCASE LEVEL)	☐
	CHECK AIR COMPRESSOR DRIVE BOX LUBE LEVEL (SAE 90W)	☐
	CHECK RADIATOR COOLANT	☐
	CHECK AIR FILTERS	☐
	CHECK HYDRAULIC OIL LEVEL	☐
	GREASE ALL UNIVERSAL JOINTS AND SLIP JOINTS	☐
	DRAIN MOISTURE FROM AIR RECEIVER TANK	☐
	GREASE LEROI AIR COMPRESSOR CLUTCH SHAFT BEARINGS	☐
	CHECK TOP HEAD GEARBOX OIL LEVEL	☐
	GREASE TRAVELING SHEAVE PINS	☐
	CHECK HYD. OIL TANK LEVEL	☐
	GREASE STANDPIPE PLUG VALVES	☐
	CHECK ALL AIR HOSE SAFETY CHAINS	☐
	GREASE: BOTTOM SHEAVE ASSEMBLY	☐
	CROWN SHEAVE ASSEMBLY	☐
	TOP HEAD DRIVE ASSEMBLY	☐
	COMPRESSOR CLUTCH & DRIVE ASSEMBLY	☐
	CLUTCH SHAFT ASSEMBLY	☐
	TOP HEAD/SWIVEL ROLLERS	☐
	NOTE: ALL CLUTCHES AND BEARINGS IN ADDITION TO THOSE LISTED ABOVE.	☐

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 3/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED
MONTHLY	CHECK ALL CABLE SHEAVE PIN LOCKS CHECK DERRICK HINGE AND HOIST CYLINDER PIN LOCKS (SEE PHOTOS #3 AND 4 FOR FURTHER INFORMATION) GREASE WINCH CABLE SHEAVES CHECK ROTARY TABLE MOUNTING BOLTS (WHERE APPLICABLE) GREASE SAND REEL BEARING (SHAFT) CHECK AIR COMPRESSOR MOUNTING BOLTS CHECK LEVEL OF LUBE AND SAND REEL GEARBOX GREASE AIR SWIVEL (SEE PHOTO #2 ON THE FOLLOWING PAGES FOR FURTHER INFORMATION) CHECK TRUCK AXLE DIFFERENTIAL LUBE LEVEL CHECK CARROUSEL DRIVE GEARBOX LUBE LEVEL (SEE PHOTO #1 ON FOLLOWING PAGES FOR FURTHER INFORMATION) GREASE RETRACT GATE SHAFT BUSHING (SEE PHOTO #12 ON FOLLOWING PAGES FOR FURTHER INFORMATION) GREASE CARROUSEL BUSHINGS (SEE PHOTO #8 ON FOLLOWING PAGES FOR FURTHER INFORMATION) CHECK TRANSFER CASE MOUNTING BOLTS CHECK LEVELING JACK MOUNTING BOLTS CHECK MUD PUMP GEARBOX TORQUE BOLTS ADJUST ALL BELTS

CHECK HYDRAULIC TANK OIL LEVEL:

THE HYDRAULIC OIL RESERVOIR SHOULD BE INSPECTED DAILY AND KEPT AT THE PROPER LEVEL, USING A PREMIUM HYDRAULIC OIL. (SEE HYDRAULIC OIL RECOMMENDATIONS). FAILURE TO MAINTAIN THIS LEVEL WILL MOST CERTAINLY RESULT IN MALFUNCTION OF THE HYDRAULIC SYSTEM, OVERHEATING OF THE HYDRAULIC CIRCUIT COMPONENTS AND THE DESTRUCTION OF HYDRAULIC PUMPS AND MOTORS.

THE PROPER HYDRAULIC OIL LEVEL SHOULD BE DETERMINED AS FOLLOWS:

1. THE DERRICK SHOULD BE DOWN, JACKS FULLY RETRACTED AND THE TOP HEAD DRIVE GEARBOX IN THE RETRACT POSITION.

2. THE LIQUID LEVEL AT THIS POINT SHOULD BE WITHIN 1/4-INCH OF THE TOP OF THE LEVEL SIGHT GAUGE GLASS.

DRAIN MOISTURE FROM HYDRAULIC OIL TANK BY USING THE BLEEDER VALVE. THIS IS LOCATED UNDER THE HYDRAULIC OIL RESERVOIR AND SHOULD BE OPENED UNTIL ANY ACCUMULATED WATER HAS BEEN DRAINED OFF, BEING SPRING LOADED IT WILL SELF-CLOSE.

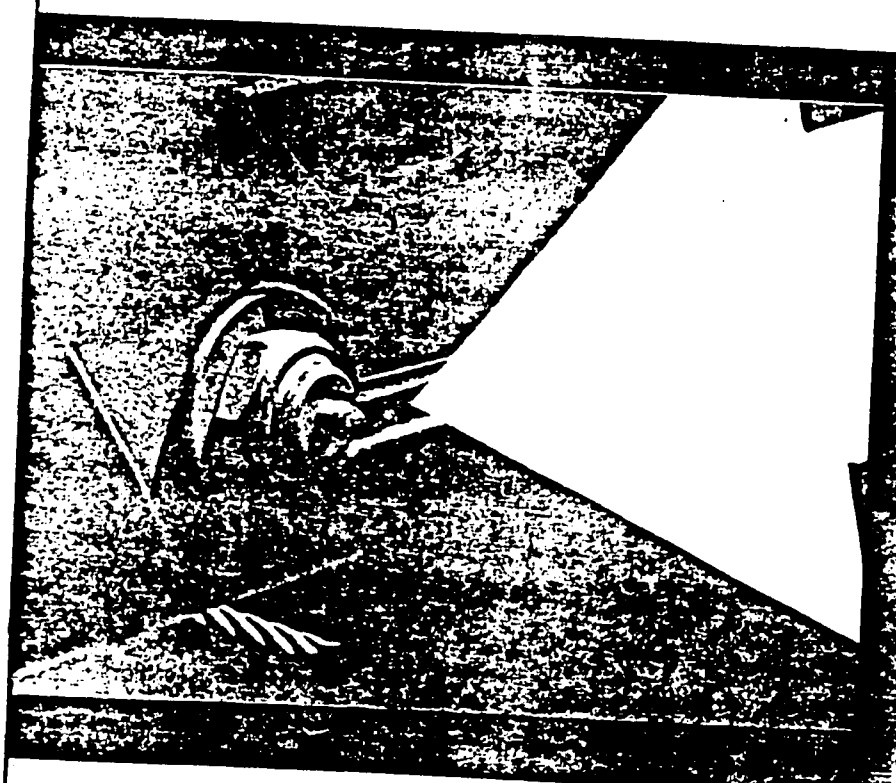
GENERAL LUBRICATION REQUIREMENTS:

FOR THE LUBRICATION REQUIREMENTS OF ANY ADDITIONAL EQUIPMENT, I.E., AIR COMPRESSOR AND ENGINES; CHECK THE SERVICE MANUAL FURNISHED BY THE MANUFACTURER OF THAT UNIT.

DERRICK HOIST CYLINDER PINS

4

The derrick hoist cylinder pins should be greased monthly.



5

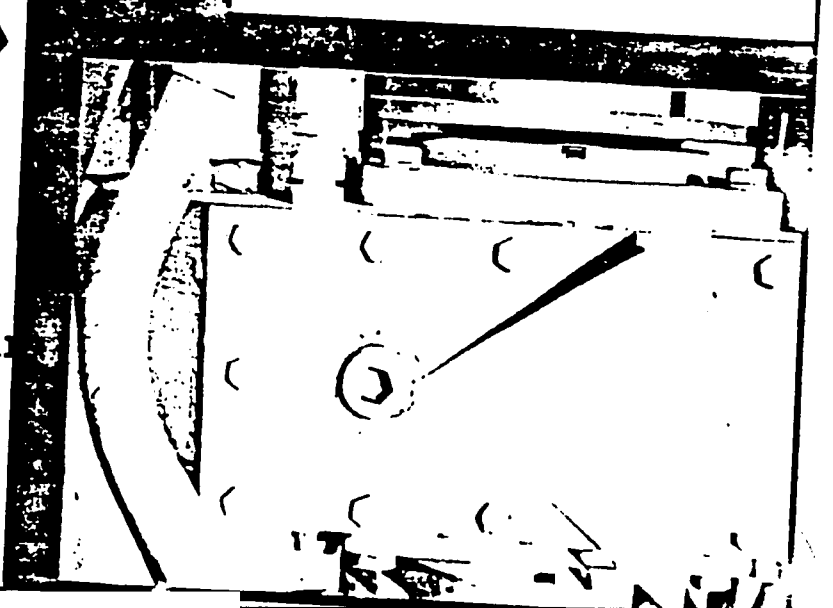
TOP BREAKOUT WRENCH PIVOT

The top breakout wrench pivot shaft should be greased weekly under ordinary drilling conditions.

TOP HEAD DRIVE GEARBOX LUBE LEVEL

6

The top head drive gearbox lube level should be checked daily by viewing the sight plug in the front gearbox cover. This lube level should be checked when the derrick is in the raised or vertical position. The level should be half way on the sight plug. An SAE 90W140W gear lube should be used.



Ingersoll-Rand

date 6/8/79 page _____ sheet 4/4

description TH-60 DERRICK LUBRICATION CHART

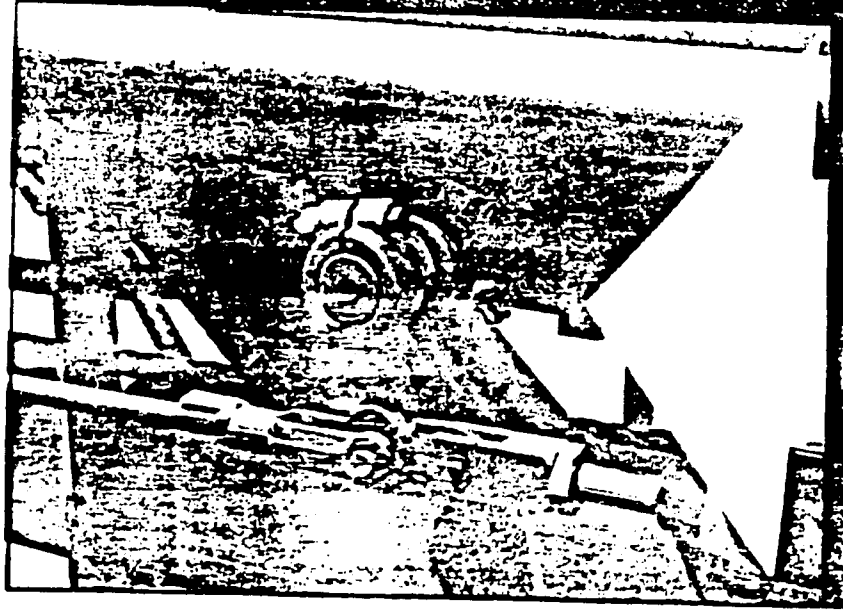
drawing no. _____

10 TRAVELING SHEAVE PINS

The traveling sheave pins should be greased daily.

TOP HEAD GEARBOX & SWIVEL ROLLER 11

The top head drive gearbox and swivel roller should be lubricated everyday using a good-grade grease.



12 RETRACT GATE SHAFT

The retract gate shaft bushings should be lubricated monthly. The derrick should be in the horizontal or lower position when lubricating this area.

Must a Hydraulic System Leak?

Absolutely not!

The aircraft industry has virtually eliminated leaks in their hydraulic systems.

The mobile equipment industry has significantly reduced leakage in their machines and systems.

How has this been accomplished? One of the factors contributing to aircraft industry success was a switch to better fittings. The mobile equipment industry improved some of their designs by shifting from pipe thread to either straight thread or flange fittings. The most important factor, however, was DETERMINATION. Once committed, these industries followed through.

The Need to Stop Leaks

It has been estimated over a hundred million gallons of oil could be saved each year if external leaks from hydraulic machines and systems were eliminated. Add to this the cost of the labor for spill clean-up, re-filling of reservoirs, etc., and the total savings potential of no-leak systems could be tens of millions of dollars per year.

The HFI Yardstick

Is there a yardstick for checking a plant's hydraulic oil use?

Mobil Oil Corporation has developed the Hydraulic Fluid Index (HFI), comparing oil consumption to machine capacity. They discovered that each year the average plant used four times more hydraulic oil (HFI=4) than its machines actually hold. Ideally, the fluid should last almost indefinitely, and the HFI should be less than one. In practice, fluid is lost through leakage, line breaks and fluid changes. Any plant can cut its HFI (oil consumption) in half by developing skilled hydraulic maintenance men who can stop leaks before they occur, and control fluid contamination.

Hydraulics

PREVENTIVE MAINTENANCE

Before getting down to the specifics of finding and fixing leaks (corrective maintenance), let's consider another important part of leakage control—preventive maintenance.

Handling Repairs

Hydraulic components are precision devices. Careless handling of them or other parts of the system can result in malfunction or failure. To avoid creating problems when installing or repairing hydraulic components, follow these tips:

1. Clean away the dirt in and around equipment before taking apart lines and removing parts.
2. Cap off all disconnected lines and open ports.
3. Protect the overhaul area from grinding dust, machining chips, and wind driven dirt.
4. Work only on metal or hard finished bench tops, easy to keep clean.
5. Handle parts carefully to avoid nicks and burrs.
6. Use lint-free cloths to wipe parts.
7. Use smooth burr-less tools, especially when working with O-rings.
8. Lubricate all sliding parts during assembly.
9. Cover sharp grooves and threads with thimble or shim stock when installing O-rings and other seals.
10. Discard all used O-rings to avoid re-use.
11. Make certain that seals are of the right size and material.
12. Use only recommended replacement parts.
13. Examine all prematurely worn or malfunctioned parts for clues as to the cause of failure.
14. Test the overhauled device before reinstalling it, if possible. It's embarrassing as well as costly to remount a repaired component in the system, only to find that it leaks or doesn't work properly.

Fluid Temperature

Petroleum oils are used in most hydraulic applications to lubricate parts as well as transmit power. As oil temperature increases, however, the lubricating film thins out. The result is rubbing parts supported by the oil film move closer together; friction and wear increase; seal materials age more quickly, become stiff and hard, and may readily permit leakage.

To avoid trouble, industrial bulk oil temperature measured at the reservoir should be kept in the 100° to 130°F. range. Why? Localized hot spots—such as the one at the shaft seal—may be 100 degrees hotter than bulk oil temperature. As bulk oil temperature rises, hot spot temperatures rise an equal amount.

A thermometer on the end of a wire and placed in the reservoir fill pipe will measure fluid temperature. Temperature stickers are available for attachment to the side of a reservoir (or suspected hot spot). Spots on the sticker permanently change color to indicate the maximum temperature.

CORRECTIVE MAINTENANCE

Finding the Leak

At first this discussion might seem absurd. After all, isn't a leak obvious? Certainly the effects of the leak are obvious . . . oil on machine, floors and product.

Remember that we must know the exact location of a leak before we can eliminate it. Anyone would be hard pressed to point immediately to the source of a leak on a machine which has oil over the top, sides, and dropping onto the floor. In fact, there might not even be a leak. The real cause might be an over-filled reservoir or a spill.

The first step then in locating leakage sources is to clean the area and watch. Focus on the four general areas where leaks can occur:

1. Fittings (commonly called connectors)
2. Hoses
3. Dynamic Seals
4. Static Seals

Most leaks occur at fittings but, too often, finding the fitting that is leaking is difficult because the fluid runs along the line and drips off at some other point. Always suspect the inaccessible connection; they are often installed carelessly because they are so hard to get to. Leaks in high pressure lines sometimes are difficult to pin-point because the fluid comes out as a mist. **(Use caution: high pressure leaks can cause personal injury.)**

Determine Cause of Leak

Once you find the location of a leak, the specific cause has to be determined before it can be corrected. A scratch in a fitting seat or a cut in a seal lip that is big enough to leak excessively can still be too small to find with the naked eye. A four power magnifying glass, used frequently to search for defects, will cut down on repeat repairs. What do you look for? The detailed information in the following sections will help you decide that. It will also help to correct leakage and prevent its reoccurrence.

THREADED FITTINGS

Types of Threads

There are two basic types of threaded joints. One has tapered thread that produces a metal-to-metal seal by wedging surfaces together as the pipe is screwed in. The other has straight threads and no wedging action, but has a rubberlike element that does the sealing.

Tapered threads have the advantage that an additional fraction of a turn usually will cure a slight leak. Their sealing ability, however, depends on how perfectly they are formed. In practice, threads are often carelessly machined and won't seal regardless of how much they are tightened. In such cases excessive torques are applied, and yielding or cracking results. Because of the frequency of such leaks there is a trend to quit using tapered pipe threads. Some companies limit their use to low pressure (below 500 psi) lines.

USA Standard (Symbol NPT)

The USA Standard pipe thread is tapered and shaped to engage mating threads on their flanks as shown in figure 1. This leaves a small spiral groove along their tips that must be closed with sealer (dope). The sealer also lubricates the threads and prevents galling.

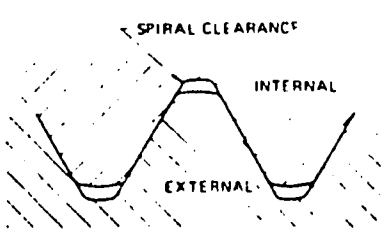


Figure 1 WRENCH TIGHT NPT THREAD

USA Standard Dryseal (Symbol NPTF)

These are very similar to NPT pipe threads, except they are shaped to make first contact at their roots and crests as shown in Figure 2. When the joint is pulled up tight with a wrench the thread crests are crushed until the thread flanks make full contact as shown in Figure 3. They don't have the built-in leakage path of the National thread but they can still leak due to machining imperfections. Dope should still be used on these threads for a lubricant but dope can't be expected to seal a poorly cut thread.

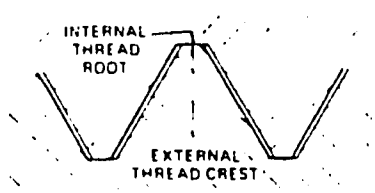


Figure 2 HAND TIGHT DRYSEAL NPTF

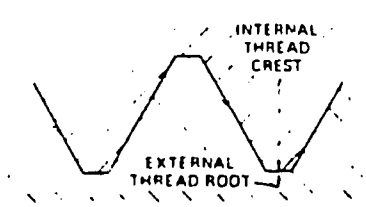


Figure 3 WRENCH TIGHT DRYSEAL NPTF

EXAMPLES OF PREMIUM GRADE ANTI–WEAR HYDRAULIC FLUIDS:

Chart 2 is a list showing the operating temperature ranges provided by a variety of anti wear fluids. The desired viscosity of 100 SSU to 200 SSU will be maintained if operating temperatures fall within these limits.

Oil sold by listed suppliers under other trade names may not always be premium grade anti-wear fluids. Many formulations are being offered which lack certain additives and are formulated for special reasons such as lower cost, high detergency, tackiness, leakage, control, etc.

Many of these can be used successfully, but the user should be aware of the difference between these fluids and "premium" fluids. For some applications, all the normal additives are not required; on others, conditions may dictate the use of special additives. Before using these fluids, their characteristics should be thoroughly reviewed. There are no doubt other premium oils available and revisions to this list may be made periodically.

CHART 2

MANUFACTURER	FLUID NAME	VISCOSITY (SSU) AT 180°F	SYSTEM OPERATING TEMPERATURE WHICH WILL MAINTAIN VISCOSITY OF 100/200 SSU
Atlantic	Hytherm FX	120 SSU	117°F/152°F
Champlin	Hydrol Medium	120 SSU	116°F/150°F
Chevron	Chevron EP 15	120 SSU	117°F/152°F
Cities Service	Pacemaker XD–20	106 SSU	102°F/134°F
Continental	Conoco Super 21	109 SSU	103°F/136°F
Gulf	Harmony 48 AW	106 SSU	101°F/134°F
Houghton	Hydro-Drive HP-200	107 SSU	100°F/133°F
Humble	Nuto H 48	107 SSU	101°F/133°F
Mobile	DTE 25	118 SSU	103°F/137°F
Pure (Div. of Union)	Puropale AW 300	93 SSU	116°F/151°F
Shell	Tellus 929	108 SSU	103°F/135°F
Sinclair	Duro AW 21	105 SSU	100°F/134°F
Standard Oil of Ohio	Industron FF 48	107 SSU	102°F/136°F
Sun	Sunvis 821 WR	109 SSU	103°F/136°F
Texaco	Rando HD B	115 SSU	106°F/139°F
Tower	Hydroil AW–4	109 SSU	105°F/135°F
Withrow	Withrolube 656	111 SSU	105°F/138°F

LOW TEMPERATURE START-UP CONSIDERATIONS:

Where reservoirs and/or systems are located outside or in unheated buildings and low ambient temperatures (below +20°F) prevail seasonally or regularly, viscosity of the normally recommended fluid may increase to an extent that it affects hydraulic components at starting and warm-up. Under certain conditions, it may be necessary to change fluids seasonally to assure maximum system efficiency and life.

Where low start-up temperatures prevail, the fluid must have a low pour point and also meet the viscosity requirements. This may require a special fluid. Consult your oil supplier or I. R. Cyclone Drill.

SEAL COMPOUND FLUID COMPATIBILITY:

With the fluids listed in this guide, no compatibility problems due to seal compounds and fluids would be anticipated. It is recommended that fluids other than these listed be given careful consideration as to compatibility with seal material. Incompatible fluids could affect seals by shrinkage, swelling and deterioration.

I. R. Cyclone recognizes that many field applications require the use of other petroleum fluids, such as emulsions, water-glycols and fire-resistant materials.

We recommend that our engineering consideration be given to applications requiring the use of these materials.

SYSTEM CLEANLINESS:

Cleanliness of fluids is of extreme importance. Experience has shown that the life of hydraulic components is directly proportional to system cleanliness. It is our recommendation that all filter elements have a 10 micron rating or finer.

Attachment 2.

Quantity of Air Required:

Cubic feet of free air per gallon of water $= \dfrac{H}{C \times \log_{10}\left(\frac{S+34}{34}\right)}$.

where H = total lift in feet; S = submergence of eductor pipe in feet when pumping; and C = a constant from the following table:

Submergence (in %)	75	70	65	60	55	50	45	40	35
C*	366	358	348	335	318	296	272	246	216
C**	330	322	306	285	262	238	214	185	162

* - Air pipe outside of eductor pipe.
** - Air pipe inside of eductor pipe.

Starting and Operating Pressures:

Starting Pressure (lbs/sq in) = 0.434 x Starting Submergence (S_s in ft)

Operating Pressure (lbs/sq in) = 0.434 x Submergence (S) in feet + friction drop (lbs/sq in) in air pipe from compressor to foot piece

Velocities:

With a straight eductor pipe the best discharge velocity of the mixture of air and water for lifts from 40 to 200 feet varies from 2000 feet per minute at 35 percent submergence to 700 feet per minute at 70 percent submergence.

With a tapered eductor pipe (smaller diameter at foot piece) the best discharge velocity is 1400 feet per minute at 35 percent submergence and 550 feet per minute at 70 percent submergence.

The best velocity for the mixture of water and air at the entrance to the bottom of the eductor pipe is 800 feet per minute at 35 percent submergence and 450 feet per minute at 70 percent submergence.

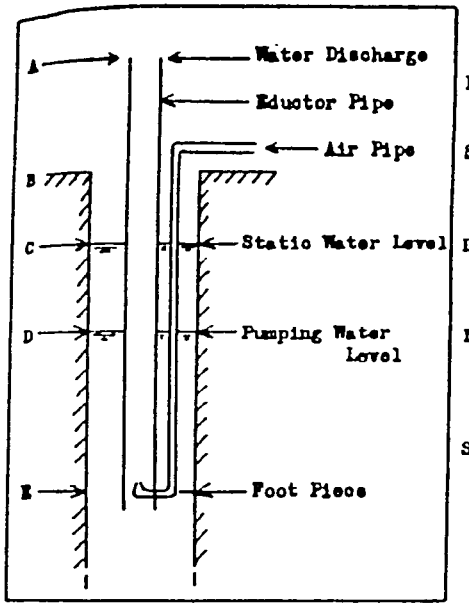
The proper size of eductor pipe can be computed from these velocities, using the formula Q = A x V, where Q is the combined volume of water and air (with allowance for pressure in calculating the air volume), A is the cross-sectional area of the eductor pipe, and V is the velocity of the air-water mixture.

Ordinary practice places velocities of the compressed air in the air pipe at from 1800 to 2400 feet per minute. The diameter of the air pipe can be computed by the formula:

$$d = 13.54\sqrt{\frac{Q}{V}}$$

where d is the diameter of the pipe in inches, Q is the volume of air in cubic feet per minute passing through the pipe, and V the velocity of flow of the air in feet per minute.

—Courtesy Compressed Air Magazine



Terms & Definitions
(See Diagram At Left)

Elevation: Lift above ground level, or the distance A-B.

Static Level: Distance water stands below ground level when not pumping, or B-C.

Draw-down: Distance the water drops in well during pumping, or C-D.

Lift (H): Total distance (vertical) water is raised from the pumping level to discharge, or A-D.

Submergence (S): Submergence of the eductor pipe when pumping, or D-E. (Often expressed in percentage of lift, or D-E/A-E).

(Starting Submergence (S_s) is for non-pumping condition, or C-E).

CUSTOMARY ALLOWABLE AND BEST SUBMERGENCES (S)

Lift in Feet (H)	Customary Allowable Percentage Submergence	Best Percentage Submergence	Type Compressor
20	55 to 70 %	65 to 70 %	Single Stage
30	55 to 70	65 to 70	"
40	50 to 70	65 to 70	"
50	50 to 70	65 to 70	"
60	50 to 70	65 to 70	"
80	50 to 70	65 to 70	"
100	45 to 70	65 to 70	"
125	45 to 65	65	"
150	40 to 65	60 to 65	"
175	40 to 60	55 to 60	"
200	40 to 60	55 to 60	Compound
250	40 to 60	55 to 60	"
300	37 to 55	50 to 55	"
350	37 to 55	50 to 55	"
400	37 to 50	45 to 50	"
450	35 to 45	40 to 45	"
500	35 to 45	40 to 45	"
550	35 to 45	40 to 45	"
600	35 to 45	40 to 45	"
650	35 to 45	40 to 45	"
700	35 to 40	40	"

—Courtesy Compressed Air Magazine

RECOMMENDED LUBRICANT SOURCES

SAE 90 GEAR LUBE:	SOHIO GEAR EP 90
SAE 30 CRANKCASE OIL:	SOHIO FACTO SAE 30
PISTON COMPRESSOR OIL:	SOHIO ELDORAN A-48
SCREW COMPRESSOR OIL:	MOBIL SHC 626
GREASE	SOHIO BEARING GUARD NO. 2, ATLANTIC RICHFIELD CALDRON, EP1, ASHLAND VALVOLINE DB-2.
ROCK DRILL OIL:	SOHIO FACTOWAY 70

* * * * * * WARNING! * * * * * *

FAILURE TO COMPLY WITH THE FOLLOWING PROCEDURES MAY RESULT IN SERIOUS DAMAGE TO ANY OR ALL PARTS OF YOUR CYCLONE DRILL MACHINE!!

LUBRICATION SPECIFICATIONS FOR

INGERSOLL-RAND SCREW COMPRESSOR TRANSFER CASE

The Cotta Company has recommended that an SAE 140-weight gear lube be used in the transfer case unit (Ingersoll-Rand part number TH-P-1754 or TH-P-1755) when it is operating in ambient temperatures above 32°F. This SAE 140-weight gear lube should be of the non-foaming, or E.P., type and should conform to military specification 2105.

Be sure to check for proper lube level, as indicated by the level plugs on the side of the transfer case just above the input shaft level. Do NOT overfill this transfer case with lubricating oil.

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 1/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED
DAILY	CHECK ENGINE CRANKCASE OIL
	CHECK AIR COMPRESSOR OIL (TANK OR CRANKCASE LEVEL)
	CHECK AIR COMPRESSOR DRIVE BOX LUBE LEVEL (SAE 90W)
	CHECK RADIATOR COOLANT
	CHECK AIR FILTERS
	CHECK HYDRAULIC OIL LEVEL
	GREASE ALL UNIVERSAL JOINTS AND SLIP JOINTS
	DRAIN MOISTURE FROM AIR RECEIVER TANK
	GREASE LEROI AIR COMPRESSOR CLUTCH SHAFT BEARINGS
	CHECK TOP HEAD GEARBOX OIL LEVEL
	GREASE TRAVELING SHEAVE PINS
	CHECK HYD. OIL TANK LEVEL
	GREASE STANDPIPE PLUG VALVES
	CHECK ALL AIR HOSE SAFETY CHAINS
	GREASE: BOTTOM SHEAVE ASSEMBLY
	CROWN SHEAVE ASSEMBLY
	TOP HEAD DRIVE ASSEMBLY
	COMPRESSOR CLUTCH & DRIVE ASSEMBLY
	CLUTCH SHAFT ASSEMBLY
	TOP HEAD/SWIVEL ROLLERS
	NOTE: ALL CLUTCHES AND BEARINGS IN ADDITION TO THOSE LISTED ABOVE.

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 2/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED	
WEEKLY		
	CHECK ALL U-JOINT AND FLANGE BOLTS FOR PROPER TORQUE	☐
	INSPECT RIG FOR HYDRAULIC AIR AND WATER LEAKS	☐
	CHECK BATTERY LIQUID LEVEL	☐
	GREASE BREAKOUT WRENCH PIVOT BOSS (SEE PHOTO #5 ON FOLLOWING PAGES FOR FURTHER INFORMATION)	☐
	CHECK HYDRAULIC TANK AND CONNECTIONS	☐
	GREASE DERRICK HINGE PINS AND HOIST CYLINDER PINS	☐
	GREASE LEROI AIR COMPRESSOR CLUTCH RELEASE COLLAR	☐
	LUBRICATE TRANSFER CASE BEARINGS (CYCLONE T-CASE)	☐
	CHECK TRUCK MAIN TRANSMISSION LUBE LEVEL	☐
	CHECK PUMP DRIVE GEARBOX LUBE LEVEL	☐
	TRUCK POWER STEERING RESERVOIR	☐
	GREASE OIL COOLER BELT SHEAVE (LEROI OPTIONS ONLY)	☐
	CHECK TRANSFER CASE OIL LEVEL (FULLER OR SPICER)	☐
	GREASE SAND REEL BEARINGS (DRUM)	☐
EVERY 2 WEEKS	CLEAN AIR COMPRESSOR PILOT VALVE	☐
	GREASE FAN SHAFT BEARINGS	☐
	CHECK MUD PUMP DRIVE GEARBOX LUBE LEVEL	☐

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 3/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED
MONTHLY	CHECK ALL CABLE SHEAVE PIN LOCKS
	CHECK DERRICK HINGE AND HOIST CYLINDER PIN LOCKS (SEE PHOTOS #3 AND 4 FOR FURTHER INFORMATION)
	GREASE WINCH CABLE SHEAVES
	CHECK ROTARY TABLE MOUNTING BOLTS (WHERE APPLICABLE)
	GREASE SAND REEL BEARING (SHAFT)
	CHECK AIR COMPRESSOR MOUNTING BOLTS
	CHECK LEVEL OF LUBE AND SAND REEL GEARBOX
	GREASE AIR SWIVEL (SEE PHOTO #2 ON THE FOLLOWING PAGES FOR FURTHER INFORMATION)
	CHECK TRUCK AXLE DIFFERENTIAL LUBE LEVEL
	CHECK CARROUSEL DRIVE GEARBOX LUBE LEVEL (SEE PHOTO #1 ON FOLLOWING PAGES FOR FURTHER INFORMATION)
	GREASE RETRACT GATE SHAFT BUSHING (SEE PHOTO #12 ON FOLLOWING PAGES FOR FURTHER INFORMATION)
	GREASE CARROUSEL BUSHINGS (SEE PHOTO #8 ON FOLLOWING PAGES FOR FURTHER INFORMATION)
	CHECK TRANSFER CASE MOUNTING BOLTS
	CHECK LEVELING JACK MOUNTING BOLTS
	CHECK MUD PUMP GEARBOX TORQUE BOLTS
	ADJUST ALL BELTS

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 4/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED	
EVERY 2 MONTHS	CHANGE ENGINE OIL	☐
	REPLACE ENGINE OIL FILTER	☐
	CLEAN COOLING SYSTEM	☐
	CHANGE TOP HEAD GEARBOX OIL	☐
	LUBE AIR CONTROL VALVES	☐
	CHANGE FUEL FILTERS	☐
	CHANGE AIR COMPRESSOR FILTER ELEMENTS	☐
	CHANGE TRUCK ENGINE AIR FILTER ELEMENT	☐
EVERY 6 MONTHS	CHANGE HYDRAULIC OIL	☐
	CHANGE ALL HYDRAULIC OIL FILTERS	☐
	CLEAN ALL ELECTRICAL CONNNECTIONS	☐
	CHANGE AIR COMPRESSOR OIL FILTER ELEMENTS (OR 500 HOURS - WHICHEVER COMES FIRST)	☐
	CLEAN BATTERY POSTS	☐
	CHANGE MAIN TRANSMISSION OIL	☐
	CHANGE LEROI AIR COMPRESSOR GEARBOX OIL (SAE 140)	☐
	CHANGE TOP HEAD GEARBOX LUBE OIL (SAE 90)	☐
	CHANGE PUMP DRIVE GEARBOX OIL (SAE 90)	☐
	CHECK ALL GEARBOX BREATHERS	☐
	CHECK ENGINE ANTI-FREEZE	☐
	CHANGE CARROUSEL DRIVE BOX OIL	☐
	CHANGE MUD PUMP DRIVE GEARBOX OIL	☐
EVERY 12 MONTHS	CHANGE ROTARY SCREW COMPRESSOR OIL MOBIL SHC 626 (OR 1000 HOURS - WHICHEVER COMES FIRST)	☐

CHECK HYDRAULIC TANK OIL LEVEL:

THE HYDRAULIC OIL RESERVOIR SHOULD BE INSPECTED DAILY AND KEPT AT THE PROPER LEVEL, USING A PREMIUM HYDRAULIC OIL. (SEE HYDRAULIC OIL RECOMMENDATIONS). FAILURE TO MAINTAIN THIS LEVEL WILL MOST CERTAINLY RESULT IN MALFUNCTION OF THE HYDRAULIC SYSTEM, OVERHEATING OF THE HYDRAULIC CIRCUIT COMPONENTS AND THE DESTRUCTION OF HYDRAULIC PUMPS AND MOTORS.

THE PROPER HYDRAULIC OIL LEVEL SHOULD BE DETERMINED AS FOLLOWS:

1. THE DERRICK SHOULD BE DOWN, JACKS FULLY RETRACTED AND THE TOP HEAD DRIVE GEARBOX IN THE RETRACT POSITION.

2. THE LIQUID LEVEL AT THIS POINT SHOULD BE WITHIN 1/4-INCH OF THE TOP OF THE LEVEL SIGHT GAUGE GLASS.

DRAIN MOISTURE FROM HYDRAULIC OIL TANK BY USING THE BLEEDER VALVE. THIS IS LOCATED UNDER THE HYDRAULIC OIL RESERVOIR AND SHOULD BE OPENED UNTIL ANY ACCUMULATED WATER HAS BEEN DRAINED OFF, BEING SPRING LOADED IT WILL SELF-CLOSE.

GENERAL LUBRICATION REQUIREMENTS:

FOR THE LUBRICATION REQUIREMENTS OF ANY ADDITIONAL EQUIPMENT, I.E., AIR COMPRESSOR AND ENGINES; CHECK THE SERVICE MANUAL FURNISHED BY THE MANUFACTURER OF THAT UNIT.

Ingersoll-Rand

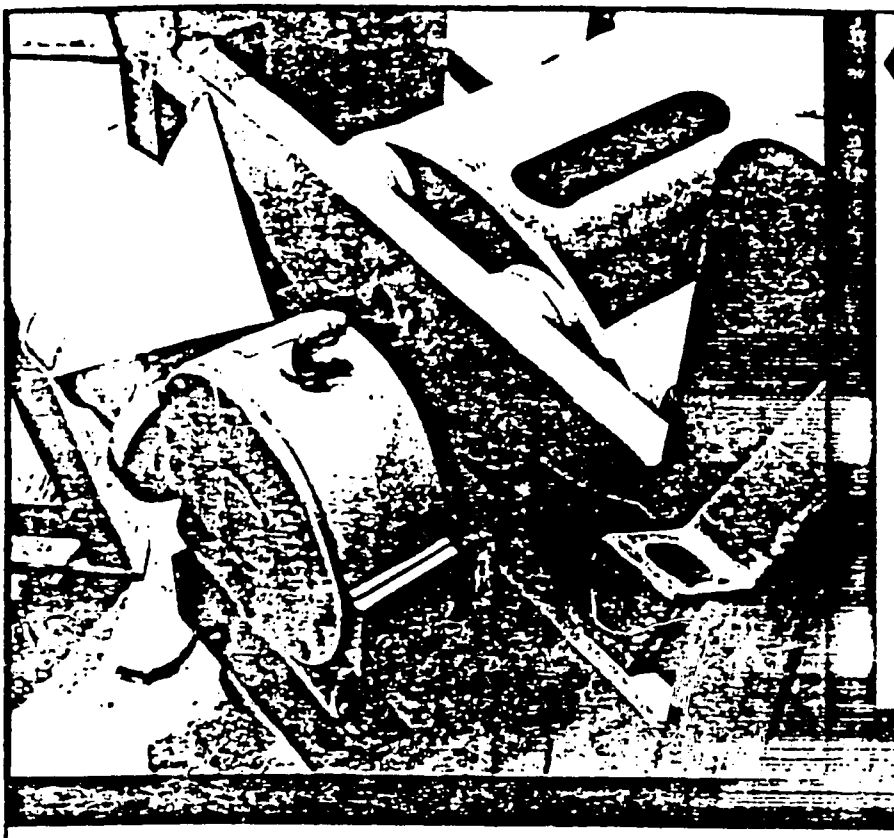
date 9-14-78

page

sheet 1 of 4

description TH60 DERRICK LUBRICATION CHART

drawing no.



1

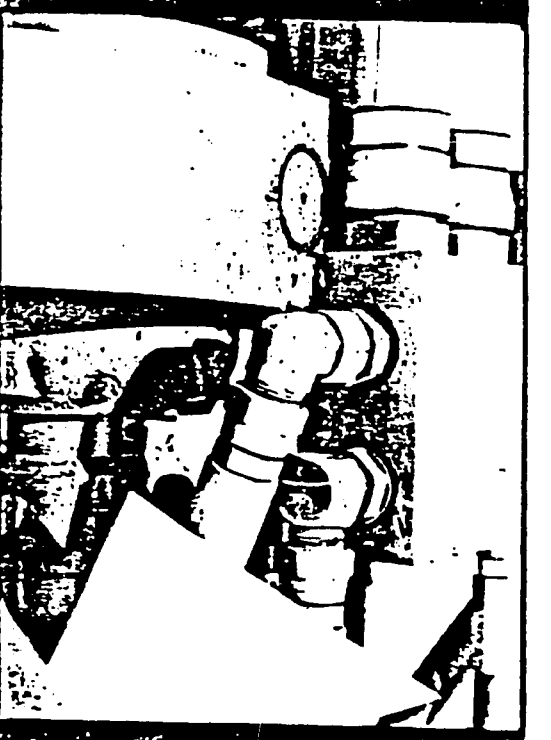
CARROUSEL DRIVE GEARBOX

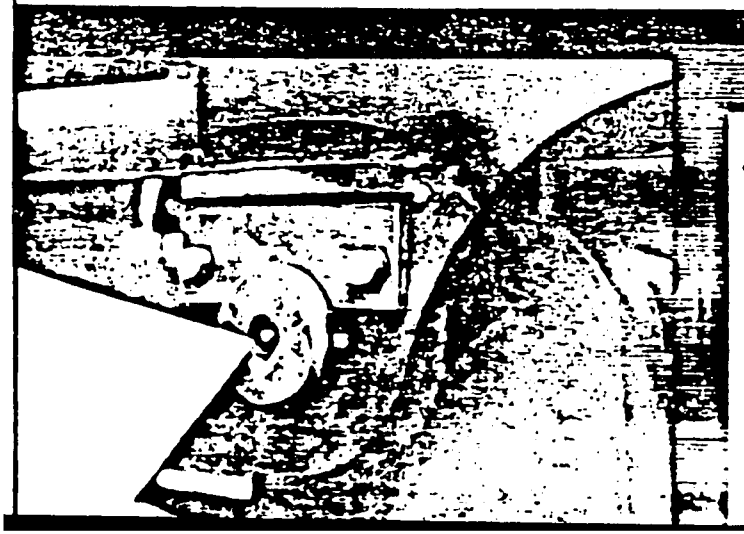
The lube level in the carrousel drive gearbox should be checked monthly. The derrick should be in the vertical or raised position when checking the lube level of this unit. The lube level should be filled to the 90° elbow with SAE 90W gear lube.

2

KING SWIVEL THRUST BEARING

The King Swivel bearing should be lubricated monthly under ordinary drilling conditions. Over-lubrication of this swivel may cause premature seal and bearing failure. A good-grade of petroleum-base grease should be used. It is not advisable to use grease containing Graphite or Moly for this application.





3

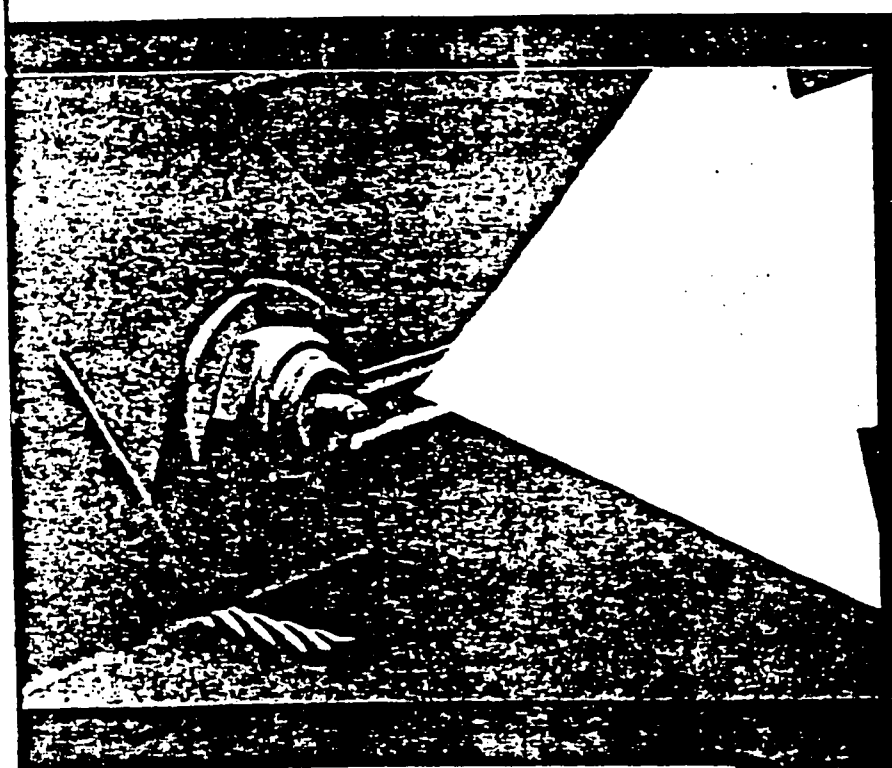
DERRICK HINGE PINS

The derrick hinge pins should be lubricated monthly.

4

DERRICK HOIST CYLINDER PINS

The derrick hoist cylinder pins should be greased monthly.



5

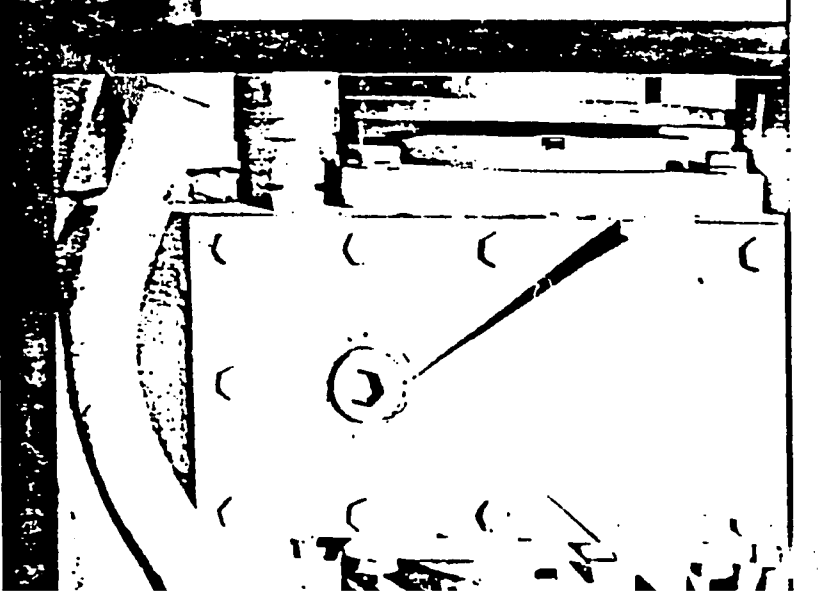
TOP BREAKOUT WRENCH PIVOT

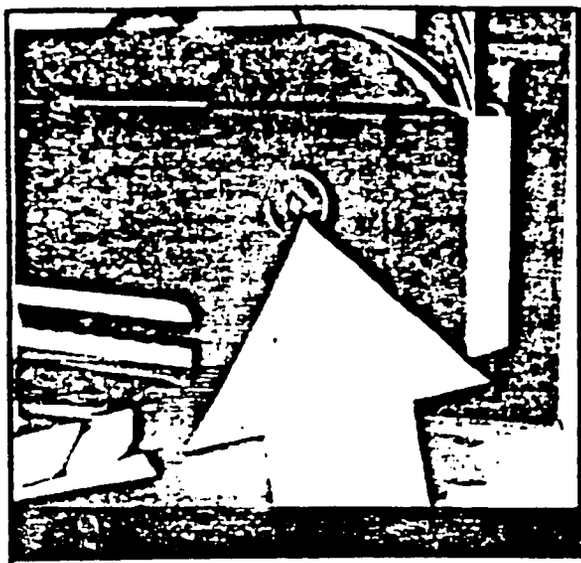
The top breakout wrench pivot shaft should be greased weekly under ordinary drilling conditions.

6

TOP HEAD DRIVE GEARBOX LUBE LEVEL

The top head drive gearbox lube level should be checked daily by viewing the sight plug in the front gearbox cover. This lube level should be checked when the derrick is in the raised or vertical position. The level should be half way on the sight plug. An SAE 90W140W gear lube should be used.



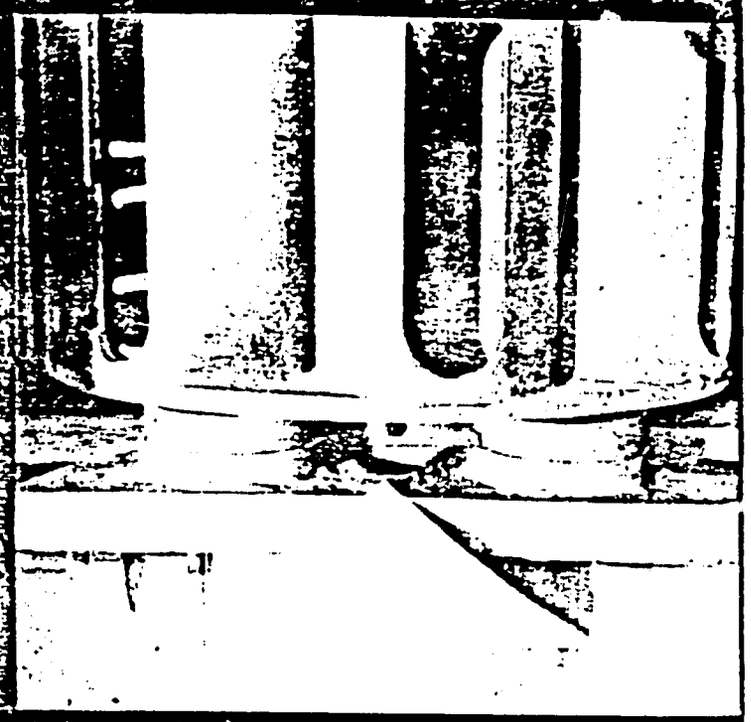


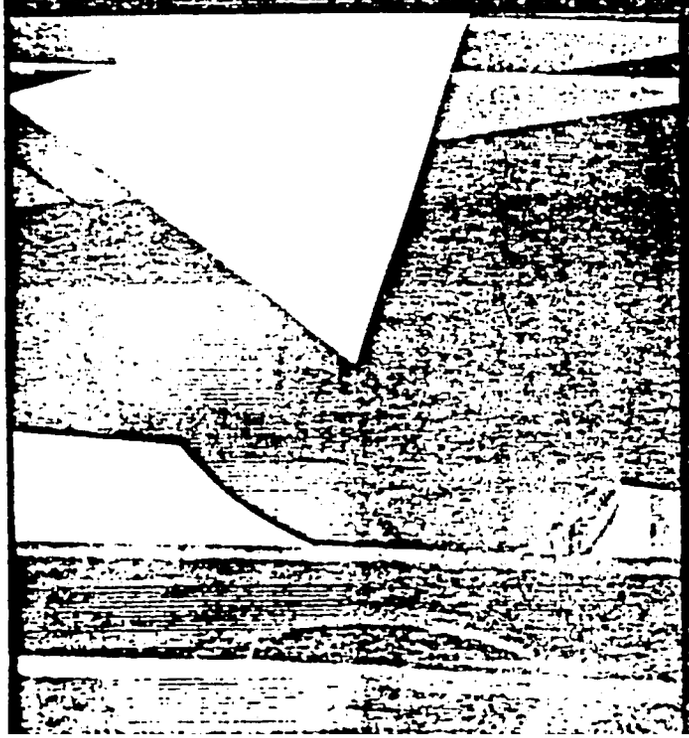
7 PULLDOWN AND PULLBACK SHEAVE PINS

The pulldown and pullback sheave pins should be greased daily. In especially dusty or muddy atmosphere, the pulldown sheave pins should be greased daily in order to purge contamination from the bushing for longer bushing life.

CARROUSEL BUSHING 8

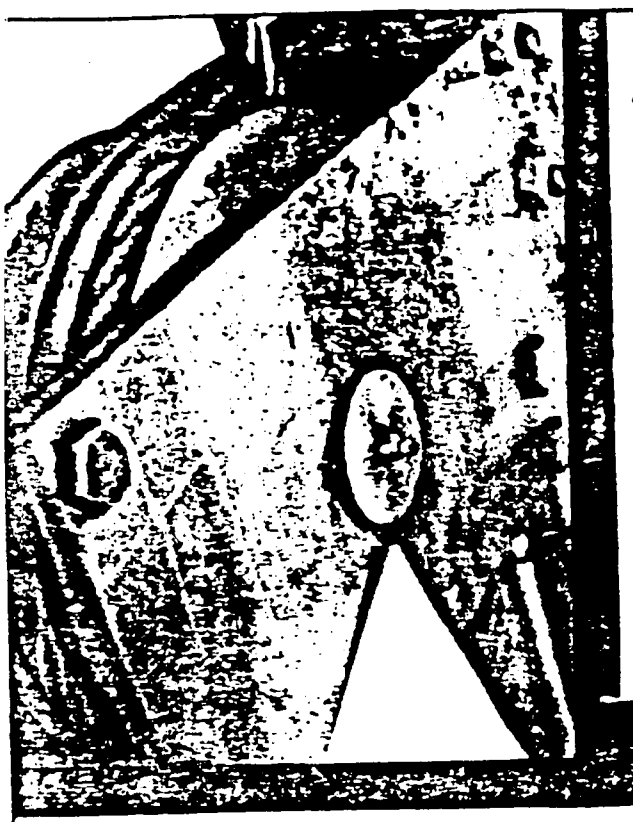
The carrousel bottom bushing should be greased monthly.





9 CROWN SHEAVES

The crown sheave pins should be lubricated daily under ordinary drilling conditions.

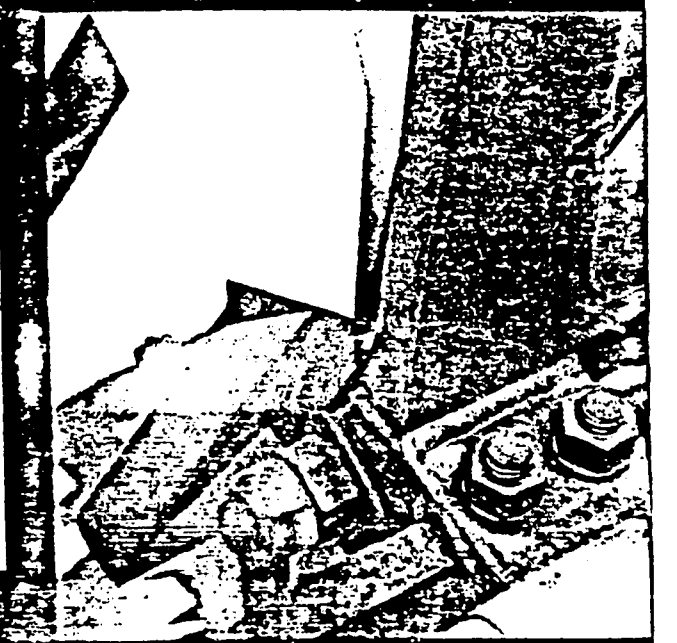


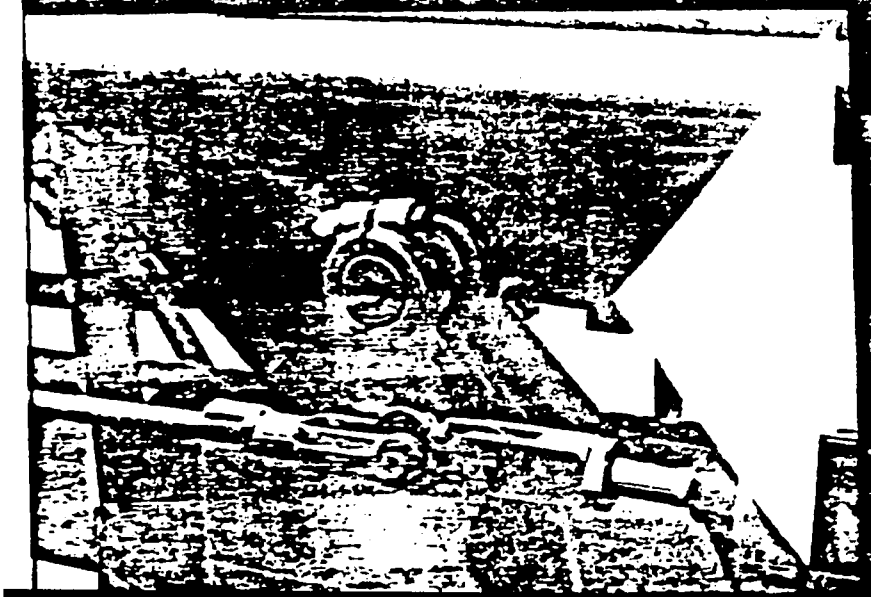
10 TRAVELING SHEAVE PINS

The traveling sheave pins should be greased daily.

TOP HEAD GEARBOX & SWIVEL ROLLER 11

The top head drive gearbox and swivel roller should be lubricated everyday using a good-grade grease.





12 RETRACT GATE SHAFT

The retract gate shaft bushings should be lubricated monthly. The derrick should be in the horizontal or lower position when lubricating this area.

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
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description HYDRAULICS TH-60
drawing no.

TH-60

HYDRAULIC CIRCUIT OPERATING PRESSURES

CIRCUIT	RELIEF PRESSURES
JACKS	2500
DERRICK HOIST	2500
WATER INJECTION	500 MYERS 1100 CAT
CARROUSEL	500
PULL DOWN	2500 MAX
PULL BACK	2500
RETRACT TABLE	2500
B. O. WRENCH	2500
TOP HEAD DRIVE	2500 DRILLING 3500 BREAKOUT
SAND REEL	1300 W/CLUTCH 2500 W/O CLUTCH
MUD PUMP	2500 5 x 6 3000 5-1/2 x 8
WINCH	2500

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Must a Hydraulic System Leak?

Absolutely not!

The aircraft industry has virtually eliminated leaks in their hydraulic systems.

The mobile equipment industry has significantly reduced leakage in their machines and systems.

How has this been accomplished? One of the factors contributing to aircraft industry success was a switch to better fittings. The mobile equipment industry improved some of their designs by shifting from pipe thread to either straight thread or flange fittings. The most important factor, however, was DETERMINATION. Once committed, these industries followed through.

The Need to Stop Leaks

It has been estimated over a hundred million gallons of oil could be saved each year if external leaks from hydraulic machines and systems were eliminated. Add to this the cost of the labor for spill clean-up, re-filling of reservoirs, etc., and the total savings potential of no-leak systems could be tens of millions of dollars per year.

The HFI Yardstick

Is there a yardstick for checking a plant's hydraulic oil use?

Mobil Oil Corporation has developed the Hydraulic Fluid Index (HFI), comparing oil consumption to machine capacity. They discovered that each year the average plant used four times more hydraulic oil (HFI=4) than its machines actually hold. Ideally, the fluid should last almost indefinitely, and the HFI should be less than one. In practice, fluid is lost through leakage, line breaks and fluid changes. Any plant can cut its HFI (oil consumption) in half by developing skilled hydraulic maintenance men who can stop leaks before they occur, and control fluid contamination.

Hydraulics

PREVENTIVE MAINTENANCE

Before getting down to the specifics of finding and fixing leaks (corrective maintenance), let's consider another important part of leakage control—preventive maintenance.

Handling Repairs

Hydraulic components are precision devices. Careless handling of them or other parts of the system can result in malfunction or failure. To avoid creating problems when installing or repairing hydraulic components, follow these tips:

1. Clean away the dirt in and around equipment before taking apart lines and removing parts.
2. Cap off all disconnected lines and open ports.
3. Protect the overhaul area from grinding dust, machining chips, and wind driven dirt.
4. Work only on metal or hard finished bench tops, easy to keep clean.
5. Handle parts carefully to avoid nicks and burrs.
6. Use lint-free cloths to wipe parts.
7. Use smooth burr-less tools, especially when working with O-rings.
8. Lubricate all sliding parts during assembly.
9. Cover sharp grooves and threads with thimble or shim stock when installing O-rings and other seals.
10. Discard all used O-rings to avoid re-use.
11. Make certain that seals are of the right size and material.
12. Use only recommended replacement parts.
13. Examine all prematurely worn or malfunctioned parts for clues as to the cause of failure.
14. Test the overhauled device before reinstalling it, if possible. It's embarrassing as well as costly to remount a repaired component in the system, only to find that it leaks or doesn't work properly.

Fluid Temperature

Petroleum oils are used in most hydraulic applications to lubricate parts as well as transmit power. As oil temperature increases, however, the lubricating film thins out. The result is rubbing parts supported by the oil film move closer together; friction and wear increase; seal materials age more quickly, become stiff and hard, and may readily permit leakage.

To avoid trouble, industrial bulk oil temperature measured at the reservoir should be kept in the 100° to 130°F. range. Why? Localized hot spots—such as the one at the shaft seal—may be 100 degrees hotter than bulk oil temperature. As bulk oil temperature rises, hot spot temperatures rise an equal amount.

A thermometer on the end of a wire and placed in the reservoir fill pipe will measure fluid temperature. Temperature stickers are available for attachment to the side of a reservoir (or suspected hot spot). Spots on the sticker permanently change color to indicate the maximum temperature.

If oil temperature in your operation exceeds 150 , determine from your oil supplier whether you are using the correct grade and quality of oil. He may recommend a higher viscosity oil with anti-wear and anti-oxidation additives

A quick test! **But approach this test carefully, because a severe burn is possible.** If you can't hold the palm of your hand on the pump inlet side of the reservoir when the system is running, the oil temperature is probably too hot.

The general rule for maximum reservoir temperature in mobile applications is ambient temperature plus 80 degrees. On a hot day, for example, of 90 degrees, bulk oil temperatures could go to 170°F. (90 + 80). Only premium oil loaded with additives is satisfactory here.

Nitrile (Buna N) seals can last almost indefinitely in 200°F. oil, but life is cut in half for every 25° temperature rise.

Fluid Temperature—°F.	Life—Hours
225	2000
250	1000
275	500

Fire resistant fluids with a water base require low temperature (130°F. maximum) to prevent excessive evaporation of water.

Fluid Contamination

"Keep it cool and keep it clean" is the secret of long fluid life. Contamination may be in the form of gas, liquid or solid; it may be chemically active or inert.

Common contaminants in hydraulic oil are:

Gas—air
Liquid—water and cutting oils
Solid—rust, chips and grit

It is usually easier to keep contaminants **out** of a system rather than remove them after they are **in** the system.

Bulk handling and the re-use of oil containers almost guarantee "new" oil will be dirty. Unless it comes from sealed quart containers, filter all "new" oil before adding it to your system.

Control solid particle contamination through filtration. Make it a practice to change all filters on a regular basis **before** they become clogged.

Fire resistant hydraulic fluids, whether water-based or non-water based, require a high standard of filtration within the circuit to maintain system reliability.

Seal Wear

In long life applications, a major cause of dynamic seal leakage is wear. Wear can also be the cause of static seal leakage. Shock, pressure surge and vibration cause static sealing surfaces to slide and separate in small amounts, where movement is measured in thousandths of an inch. Seal wear occurs and the seal eventually leaks. The rougher the sealing surfaces, the heavier the wear, and the sooner the leak occurs.

Measuring Surface Roughness

Inspectors use an electronic instrument called a profilometer to measure surface roughness and report the roughness height value in microinches (millionth of an inch). The smoother the surface, the smaller the reported value.

For static sealing, where surfaces to be sealed do not move relative to each other, commercial practice is to specify a 32 to 63 microinch (abbreviated μ in.). As long as surface separation or seal movement does not occur, satisfactory sealing is possible on surfaces with light circular tool marks up to 100. But no matter how smooth the overall surface, a nick, gouge, longitudinal scratch or spiral tool mark provides a leak path.

For dynamic sealing, the surface moving relative to the seal requires a nominal 16 microinch finish.

As a guide, the surface roughness produced by common production methods is:

Production	Roughness Height
Milling	32—250
Die Casting	32— 63
Boring, Turning	8—250
Grinding	4— 63
Polishing	4— 16

Cut Through the Jungle of Fluid Lines

If your system is a jungle of fluid lines and connections with components almost inaccessible, the odds of controlling leakage are against you.

Simplify the hydraulic system whenever possible. The fewer the connections, the fewer the possible sources of leaks. Consider back-mounting your valves, with all pipe connections made permanently to a mounting plate. Even better is the use of manifolds, which provide interconnections between valves and eliminate a lot of external plumbing.

Tubing Clamps

Shock, pressure surge, and vibration will flex metal tubing. This flexing will fatigue the tubing, particularly around line fittings. The consequences are cracked fluid lines. A well designed fluid power system will include tubing clamps to minimize shock and vibration. All tubes should be clamped on both sides of a bend, as close to the bend radius as possible.

Manufacturers generally recommended spacing between clamps as shown:

Tubing Diameter OD—in.	Distance Between Clamps—Feet
3/16—3/8	3
1/2—7/8	5
1—1 1/4	7

CORRECTIVE MAINTENANCE

Finding the Leak

At first this discussion might seem absurd. After all, isn't a leak obvious? Certainly the effects of the leak are obvious . . . oil on machine, floors and product.

Remember that we must know the exact location of a leak before we can eliminate it. Anyone would be hard pressed to point immediately to the source of a leak on a machine which has oil over the top, sides, and dropping onto the floor. In fact, there might not even be a leak. The real cause might be an over-filled reservoir or a spill.

The fir ' step then in locating leakage sources is to clean the area an watch. Focus on the four general areas where leaks can occ

1. Fittings (commonly called connectors)
2. Hoses
3. Dynamic Seals
4. Static Seals

Most leaks occur at fittings but, too often, finding the fittir that is leaking is difficult because the fluid runs along the fir and drips off at some other point. Always suspect the inaccessible connection; they are often installed carelessly because they are so hard to get to. Leaks in high pressure lines sometimes are difficult to pin-point because the fluid comes out as a mist. **(Use caution: high pressure leaks can cause personal injury.)**

Determine Cause of Leak

Once you find the location of a leak, the specific cause has to be determined before it can be corrected. A scratch in a fitting seat or a cut in a seal lip that is big enough to leak excessively can still be too small to find with the naked eye. A four power magnifying glass, used frequently to search for defects, will cut down on repeat repairs. What do you look for? The detailed information in the following sections will help you decide that. It will also help to correct leakage and prevent its reoccurrence.

THREADED FITTINGS

Types of Threads

There are two basic types of threaded joints. One has tapered thread that produces a metal-to-metal seal by wedging surfaces together as the pipe is screwed in. The other has straight threads and no wedging action, but has a rubberlike element that does the sealing.

Tapered threads have the advantage that an additional fraction of a turn usually will cure a slight leak. Their sealing ability, however, depends on how perfectly they are formed. In practice, threads are often carelessly machined and won't seal regardless of how much they are tightened. In such cases excessive torques are applied, and yielding or cracking results. Because of the frequency of such leaks there is a trend to quit using tapered pipe threads. Some companies limit their use to low pressure (below 500 psi) lines.

USA Standard (Symbol NPT)

The USA Standard pipe thread is tapered and shaped to engage mating threads on their flanks as shown in figure 1. This leaves a small spiral groove along their tips that must be closed with sealer (dope). The sealer also lubricates the threads and prevents galling.

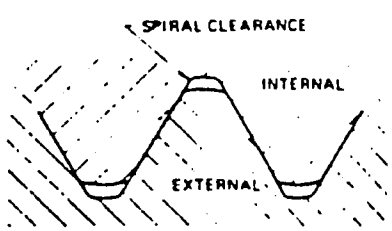

Figure 1 WRENCH TIGHT NPT THREAD

USA Standard Dryseal (Symbol NPTF)

These are very similar to NPT pipe threads, except they are shaped to make first contact at their roots and crests as shown in Figure 2. When the joint is pulled up tight with a wrench the thread crests are crushed until the thread flanks make full contact as shown in Figure 3. They don't have the built-in leakage path of the National thread but they can still leak due to machining imperfections. Dope should still be used on these threads for a lubricant but dope can't be expected to seal a poorly cut thread.

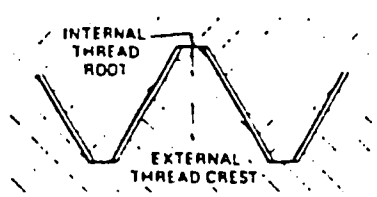

Figure 2 HAND TIGHT DRYSEAL NPTF

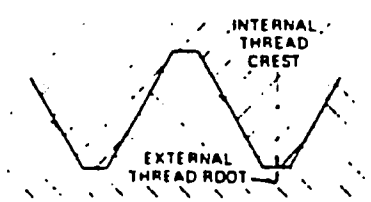

Figure 3 WRENCH TIGHT DRYSEAL NPTF

PETROLEUM BASE HYDRAULIC FLUIDS

The rapid increase in the use of more costly and sophisticated hydraulic equipment has put a greater demand on the quality of hydraulic oils required to provide satisfactory machine performances. There is also an increasing awareness on the part of the manufacturers that proper lubrication and preventive maintenance are vitally important to satisfactory machine performance.

The purpose of this bulletin is to provide guidelines for the selection of hydraulic fluids that will provide the efficiency and protection necessary for satisfactory operation of I.R. Cyclone drills.

FLUID REQUIREMENTS:

The oil qualities required by hydraulic system elements, and by operating conditions to which the oils are subjected, may be summarized as follows:

- Correct Viscosity
- High Viscosity Index
- High Film Strength and Proper Lubricity
- High Oxidation Resistance
- Good Water Separating Ability
- Good Anti-Rust Property
- Good Resistance to Foaming

Premium quality, anti-wear type hydraulic fluids, provide the most desirable balance of these qualities.

VISCOSITY:

Proper viscosity at operating temperature is probably the single most important property the fluid must possess. Viscosity affects efficiency and life. It is most commonly measured in Saybolt seconds (SSU or SUS), although SAE ratings are often encountered particularly in automotive type oils.

I.R. Cyclone recommends that a fluid have a Saybolt viscosity of not less than 100 SSU at operating temperature and preferably between 100 and 200 SSU at the operating temperature of the system when running continuously. This viscosity will provide a lubricating oil film of sufficient thickness to give maximum life.

Ambient temperatures affect system temperatures especially at the extremes, high or low. This must be considered in the selection of fluids with proper viscosity to meet different temperature conditions.

The following information is provided as a guide to the selection of fluids to meet different temperature conditions.

PRIMARY RECOMMENDATION: PREMIUM QUALITY ANTI—WEAR HYDRAULIC FLUIDS:

In I.R. Cyclone hydraulic systems where the oil serves as a hydraulic fluid only, premium quality, anti-wear type hydraulic oils are recommended. These products are balanced to protect the motors, maintain proper viscosity for extended periods of time and provide trouble free filtering capabilities.

Premium hydraulic oils with viscosity indexes of 95 or above will provide the temperature and viscosity ranges shown in Chart I.

CHART I

OPERATING TEMPERATURE RANGE	VISCOSITY RANGE AT OPERATING TEMPERATURE	VISCOSITY GRADE INDUSTRY IDENTIFICATION
84°F/122°F	200/100	150 SSU
107°F/140°F	200/100	225 SSU
110°F/150°F	200/100	300 SSU
130°F/165°F	200/100	450 SSU
145°F/182°F	200/100	600 SSU*

*Consult I. R. Cyclone before using this viscosity grade fluid.

Operating temperature is the main factor in determining which viscosity grade to specify. Fluids are identified by and can be ordered by viscosity grade. For example, in a system with operating temperatures up to 150°F the chart indicates 300 SSU premium grade anti-wear fluid will provide the required viscosity range. Be sure to include the complete description.

EXAMPLES OF PREMIUM GRADE ANTI–WEAR HYDRAULIC FLUIDS:

Chart 2 is a list showing the operating temperature ranges provided by a variety of anti wear fluids. The desired viscosity of 100 SSU to 200 SSU will be maintained if operating temperatures fall within these limits.

Oil sold by listed suppliers under other trade names may not always be premium grade anti-wear fluids. Many formulations are being offered which lack certain additives and are formulated for special reasons such as lower cost, high detergency, tackiness, leakage, control, etc.

Many of these can be used successfully, but the user should be aware of the difference between these fluids and "premium" fluids. For some applications, all the normal additives are not required; on others, conditions may dictate the use of special additives. Before using these fluids, their characteristics should be thoroughly reviewed. There are no doubt other premium oils available and revisions to this list may be made periodically.

CHART 2

MANUFACTURER	FLUID NAME	VISCOSITY (SSU) AT 180°F	SYSTEM OPERATING TEMPERATURE WHICH WILL MAINTAIN VISCOSITY OF 100/200 SSU
Atlantic	Hytherm FX	120 SSU	117°F/152°F
Champlin	Hydrol Medium	120 SSU	116°F/150°F
Chevron	Chevron EP 15	120 SSU	117°F/152°F
Cities Service	Pacemaker XD–20	106 SSU	102°F/134°F
Continental	Conoco Super 21	109 SSU	103°F/136°F
Gulf	Harmony 48 AW	106 SSU	101°F/134°F
Houghton	Hydro-Drive HP-200	107 SSU	100°F/133°F
Humble	Nuto H 48	107 SSU	101°F/133°F
Mobile	DTE 25	118 SSU	103°F/137°F
Pure (Div. of Union)	Puropale AW 300	93 SSU	116°F/151°F
Shell	Tellus 929	108 SSU	103°F/135°F
Sinclair	Duro AW 21	105 SSU	100°F/134°F
Standard Oil of Ohio	Industron FF 48	107 SSU	102°F/136°F
Sun	Sunvis 821 WR	109 SSU	103°F/136°F
Texaco	Rando HD B	115 SSU	106°F/139°F
Tower	Hydroil AW–4	109 SSU	105°F/135°F
Withrow	Withrolube 656	111 SSU	105°F/138°F

SECONDARY RECOMMENDATION AUTOMOTIVE ENGINE OILS (MULTI–GRADE SAE–SERVICE CLASSIFICATION SC):

These oils are acceptable, basically because of general availability. Because different additives are required for internal combustion engines than for hydraulic service, certain filtering problems can arise when these fluids are placed in hydraulic service.

However, when high operating temperatures become the prime consideration and premium hydraulic oils of the proper viscosity are not available, multi-grade engine oil of the SAE service quality SC quality level (formerly MS) may be used with the expectation of more frequent servicing of the filter element.

Chart 3 shows the temperature and viscosity ranges of these oils. Other types of engine oils such as single grade SAE oils are not recommended because they do not have the viscosity range required, do not have the necessary additives and are more susceptible to filter problems.

EXAMPLE: For operation with system temperature up to 150°F use a 10 W 40 multi-grade SAE service classification SC oil.

CHART 3

OPERATING TEMPERATURE	VISCOSITY RANGE AT OPERATING TEMPERATURE	SAE VISCOSITY GRADE
100°F/130°F	200/100	10 W 30
140°F/190°F	200/100	10 W 40

EXAMPLES OF AUTOMOTIVE ENGINE OILS:

Where engine oils must be used because of availability, convenience, etc., we provide the following list for comparative purposes:

CHART 4

MANUFACTURER	FLUID NAME	VISCOSITY (SSU) AT 180°F	SYSTEM OPERATING TEMPERATURE RANGE WHICH WILL MAINTAIN VISCOSITY OF 100/200 SSU
Mobil	Delvac Special 10 W 30	100 SSU	115°F/160°F
Sinclair	Triplex	82 SSU	113°F/163°F
Texaco	Ursatex 10 W 30	80 SSU	115°F/165°F
Amoco	Super Permalube 10 W 30	80 SSU	112°F/160°F

LOW TEMPERATURE START-UP CONSIDERATIONS:

Where reservoirs and/or systems are located outside or in unheated buildings and low ambient temperatures (below +20°F) prevail seasonally or regularly, viscosity of the normally recommended fluid may increase to an extent that it affects hydraulic components at starting and warm-up. Under certain conditions, it may be necessary to change fluids seasonally to assure maximum system efficiency and life.

Where low start-up temperatures prevail, the fluid must have a low pour point and also meet the viscosity requirements. This may require a special fluid. Consult your oil supplier or I. R. Cyclone Drill.

SEAL COMPOUND FLUID COMPATIBILITY:

With the fluids listed in this guide, no compatibility problems due to seal compounds and fluids would be anticipated. It is recommended that fluids other than these listed be given careful consideration as to compatibility with seal material. Incompatible fluids could affect seals by shrinkage, swelling and deterioration.

I. R. Cyclone recognizes that many field applications require the use of other petroleum fluids, such as emulsions, water-glycols and fire-resistant materials.

We recommend that our engineering consideration be given to applications requiring the use of these materials.

SYSTEM CLEANLINESS:

Cleanliness of fluids is of extreme importance. Experience has shown that the life of hydraulic components is directly proportional to system cleanliness. It is our recommendation that all filter elements have a 10 micron rating or finer.

RECOMMENDED LUBRICANT SOURCES

SAE 90 GEAR LUBE:	SOHIO GEAR EP 90
SAE 30 CRANKCASE OIL:	SOHIO FACTO SAE 30
PISTON COMPRESSOR OIL:	SOHIO ELDORAN A-48
SCREW COMPRESSOR OIL:	MOBIL SHC 626
GREASE	SOHIO BEARING GUARD NO. 2, ATLANTIC RICHFIELD CALDRON, EP1, ASHLAND VALVOLINE DB-2.
ROCK DRILL OIL:	SOHIO FACTOWAY 70

* * * * * * WARNING! * * * * * *

FAILURE TO COMPLY WITH THE FOLLOWING PROCEDURES MAY RESULT IN SERIOUS DAMAGE TO ANY OR ALL PARTS OF YOUR CYCLONE DRILL MACHINE!!

LUBRICATION SPECIFICATIONS FOR INGERSOLL-RAND SCREW COMPRESSOR TRANSFER CASE

The Cotta Company has recommended that an SAE 140-weight gear lube be used in the transfer case unit (Ingersoll-Rand part number TH-P-1754 or TH-P-1755) when it is operating in ambient temperatures above 32°F. This SAE 140-weight gear lube should be of the non-foaming, or E.P., type and should conform to military specification 2105.

Be sure to check for proper lube level, as indicated by the level plugs on the side of the transfer case just above the input shaft level. Do NOT overfill this transfer case with lubricating oil.

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 1/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED
DAILY	CHECK ENGINE CRANKCASE OIL
	CHECK AIR COMPRESSOR OIL (TANK OR CRANKCASE LEVEL)
	CHECK AIR COMPRESSOR DRIVE BOX LUBE LEVEL (SAE 90W)
	CHECK RADIATOR COOLANT
	CHECK AIR FILTERS
	CHECK HYDRAULIC OIL LEVEL
	GREASE ALL UNIVERSAL JOINTS AND SLIP JOINTS
	DRAIN MOISTURE FROM AIR RECEIVER TANK
	GREASE LEROI AIR COMPRESSOR CLUTCH SHAFT BEARINGS
	CHECK TOP HEAD GEARBOX OIL LEVEL
	GREASE TRAVELING SHEAVE PINS
	CHECK HYD. OIL TANK LEVEL
	GREASE STANDPIPE PLUG VALVES
	CHECK ALL AIR HOSE SAFETY CHAINS
	GREASE: BOTTOM SHEAVE ASSEMBLY
	CROWN SHEAVE ASSEMBLY
	TOP HEAD DRIVE ASSEMBLY
	COMPRESSOR CLUTCH & DRIVE ASSEMBLY
	CLUTCH SHAFT ASSEMBLY
	TOP HEAD/SWIVEL ROLLERS
	NOTE: ALL CLUTCHES AND BEARINGS IN ADDITION TO THOSE LISTED ABOVE.

INGERSOLL-RAND®
DRILLING EQUIPMENT

page SERVICE
sheet 2/5
description PREVENTIVE MAINTENANCE CHART
drawing no.

INTERVAL	OPERATIONS TO BE PREFORMED	
WEEKLY		
	CHECK ALL U-JOINT AND FLANGE BOLTS FOR PROPER TORQUE	☐
	INSPECT RIG FOR HYDRAULIC AIR AND WATER LEAKS	☐
	CHECK BATTERY LIQUID LEVEL	☐
	GREASE BREAKOUT WRENCH PIVOT BOSS (SEE PHOTO Ø5 ON FOLLOWING PAGES FOR FURTHER INFORMATION)	☐
	CHECK HYDRAULIC TANK AND CONNECTIONS	☐
	GREASE DERRICK HINGE PINS AND HOIST CYLINDER PINS	☐
	GREASE LEROI AIR COMPRESSOR CLUTCH RELEASE COLLAR	☐
	LUBRICATE TRANSFER CASE BEARINGS (CYCLONE T-CASE)	☐
	CHECK TRUCK MAIN TRANSMISSION LUBE LEVEL	☐
	CHECK PUMP DRIVE GEARBOX LUBE LEVEL	☐
	TRUCK POWER STEERING RESERVOIR	☐
	GREASE OIL COOLER BELT SHEAVE (LEROI OPTIONS ONLY)	☐
	CHECK TRANSFER CASE OIL LEVEL (FULLER OR SPICER)	☐
	GREASE SAND REEL BEARINGS (DRUM)	☐
EVERY 2 WEEKS		
	CLEAN AIR COMPRESSOR PILOT VALVE	☐
	GREASE FAN SHAFT BEARINGS	☐
	CHECK MUD PUMP DRIVE GEARBOX LUBE LEVEL	☐

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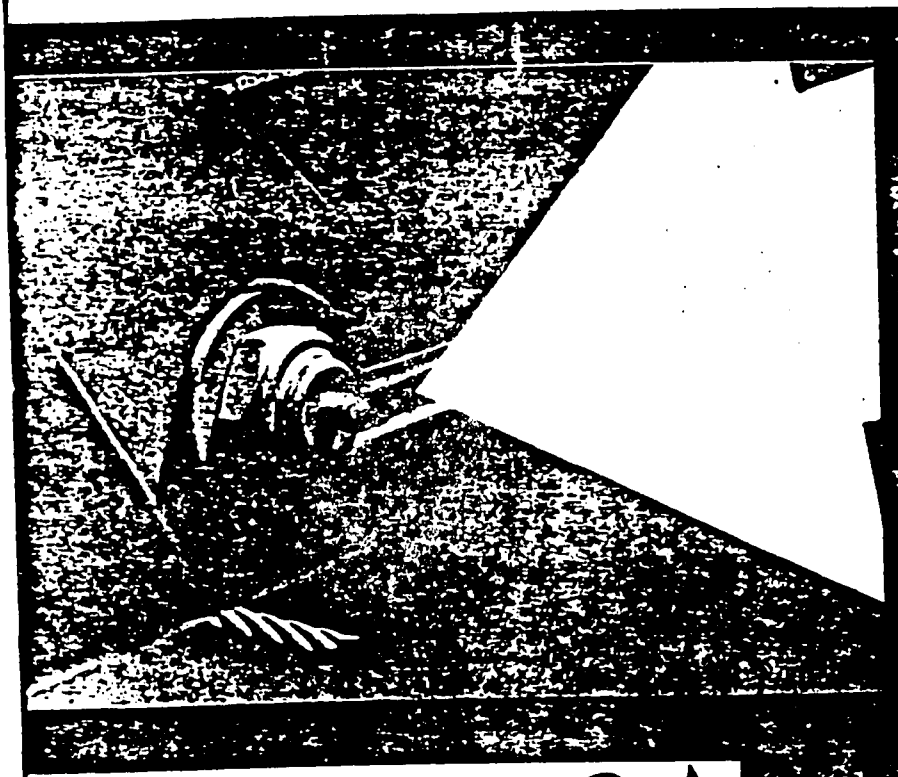
4

DERRICK HOIST CYLINDER PINS

The derrick hoist cylinder pins should be greased monthly.



5

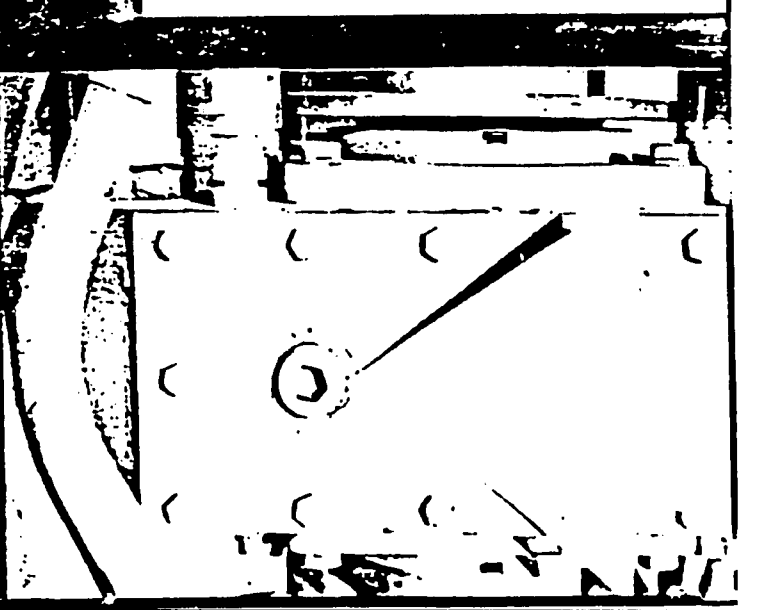
TOP BREAKOUT WRENCH PIVOT

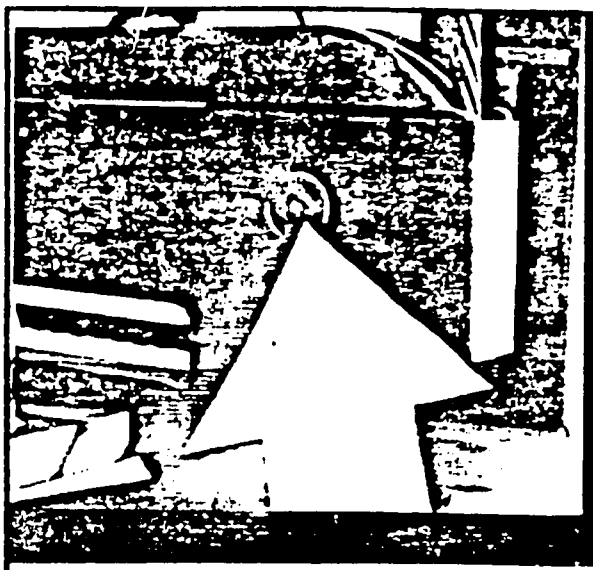
The top breakout wrench pivot shaft should be greased weekly under ordinary drilling conditions.

6

TOP HEAD DRIVE GEARBOX LUBE LEVEL

The top head drive gearbox lube level should be checked daily by viewing the sight plug in the front gearbox cover. This lube level should be checked when the derrick is in the raised or vertical position. The level should be half way on the sight plug. An SAE 90W140W gear lube should be used.



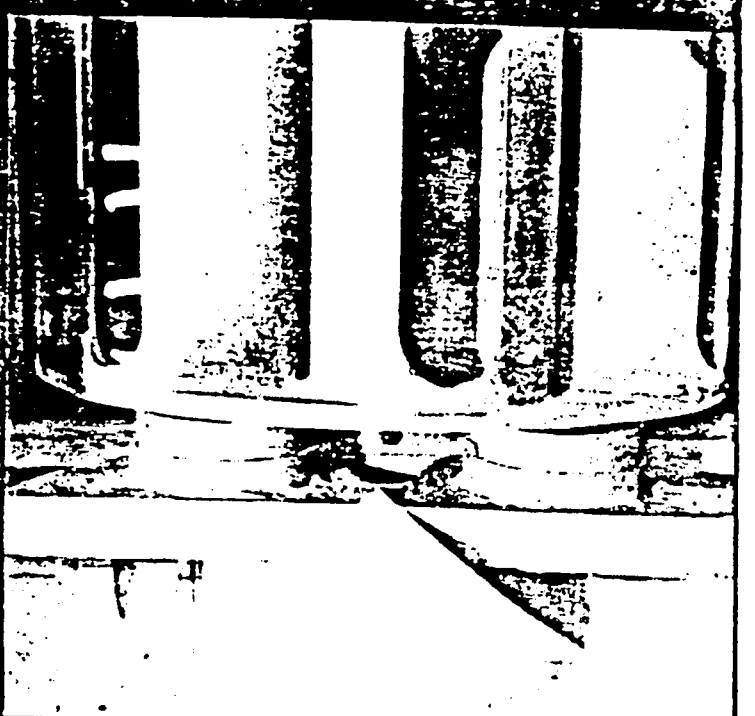


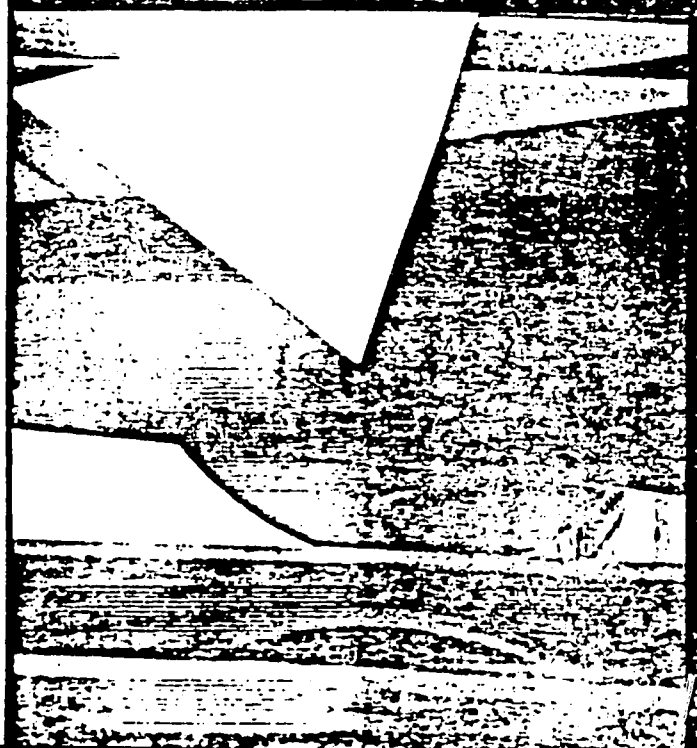
7 PULLDOWN AND PULLBACK SHEAVE PINS

The pulldown and pullback sheave pins should be greased daily. In especially dusty or muddy atmosphere, the pulldown sheave pins should be greased daily in order to purge contamination from the bushing for longer bushing life.

CARROUSEL BUSHING 8

The carrousel bottom bushing should be greased monthly.





9 CROWN SHEAVES

The crown sheave pins should be lubricated daily under ordinary drilling conditions.

Ingersoll-Rand

date 6/8/79 page ____ sheet 4/4

description TH-60 DERRICK LUBRICATION CHART

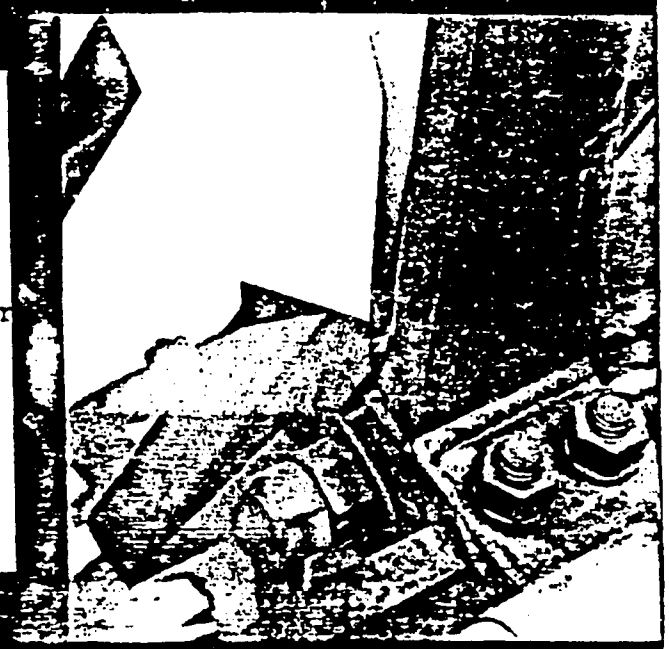
drawing no. ____

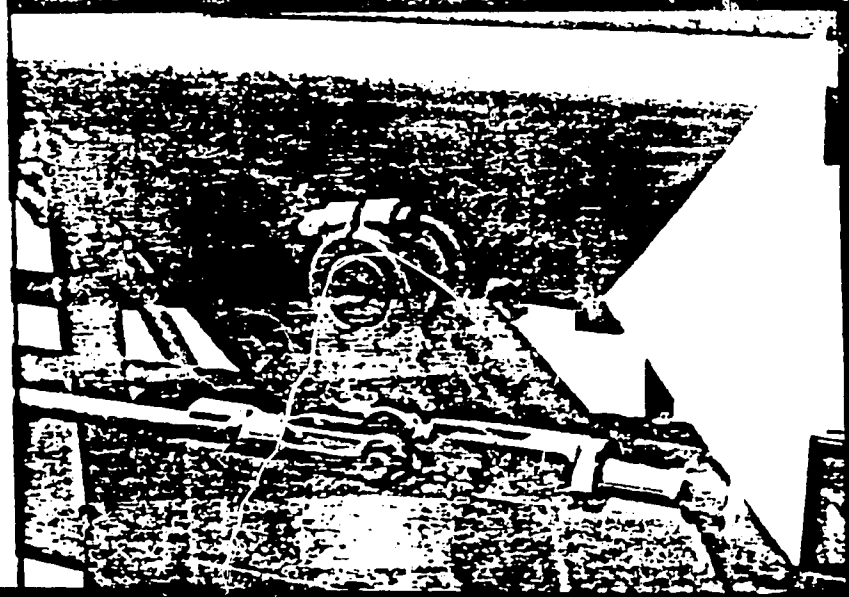
10 TRAVELING SHEAVE PINS

The traveling sheave pins should be greased daily.

TOP HEAD GEARBOX & SWIVEL ROLLER 11

The top head drive gearbox and swivel roller should be lubricated everyday using a good-grade grease.





12 RETRACT GATE SHAFT

The retract gate shaft bushings should be lubricated monthly. The derrick should be in the horizontal or lower position when lubricating this area.

TH-60

HYDRAULIC CIRCUIT OPERATING PRESSURES

CIRCUIT	RELIEF PRESSURES
JACKS	2500
DERRICK HOIST	2500
WATER INJECTION	500 MYERS 1100 CAT
CARROUSEL	500
PULL DOWN	2500 MAX
PULL BACK	2500
RETRACT TABLE	2500
B. O. WRENCH	2500
TOP HEAD DRIVE	2500 DRILLING 3500 BREAKOUT
SAND REEL	1300 W/CLUTCH 2500 W/O CLUTCH
MUD PUMP	2500 5 x 6 3000 5-1/2 x 8
WINCH	2500

CHECK HYDRAULIC TANK OIL LEVEL:

THE HYDRAULIC OIL RESERVOIR SHOULD BE INSPECTED DAILY AND KEPT AT THE PROPER LEVEL, USING A PREMIUM HYDRAULIC OIL. (SEE HYDRAULIC OIL RECOMMENDATIONS). FAILURE TO MAINTAIN THIS LEVEL WILL MOST CERTAINLY RESULT IN MALFUNCTION OF THE HYDRAULIC SYSTEM, OVERHEATING OF THE HYDRAULIC CIRCUIT COMPONENTS AND THE DESTRUCTION OF HYDRAULIC PUMPS AND MOTORS.

THE PROPER HYDRAULIC OIL LEVEL SHOULD BE DETERMINED AS FOLLOWS:

1. THE DERRICK SHOULD BE DOWN, JACKS FULLY RETRACTED AND THE TOP HEAD DRIVE GEARBOX IN THE RETRACT POSITION.

2. THE LIQUID LEVEL AT THIS POINT SHOULD BE WITHIN 1/4-INCH OF THE TOP OF THE LEVEL SIGHT GAUGE GLASS.

DRAIN MOISTURE FROM HYDRAULIC OIL TANK BY USING THE BLEEDER VALVE. THIS IS LOCATED UNDER THE HYDRAULIC OIL RESERVOIR AND SHOULD BE OPENED UNTIL ANY ACCUMULATED WATER HAS BEEN DRAINED OFF, BEING SPRING LOADED IT WILL SELF-CLOSE.

GENERAL LUBRICATION REQUIREMENTS:

FOR THE LUBRICATION REQUIREMENTS OF ANY ADDITIONAL EQUIPMENT, I.E., AIR COMPRESSOR AND ENGINES; CHECK THE SERVICE MANUAL FURNISHED BY THE MANUFACTURER OF THAT UNIT.

Ingersoll-Rand

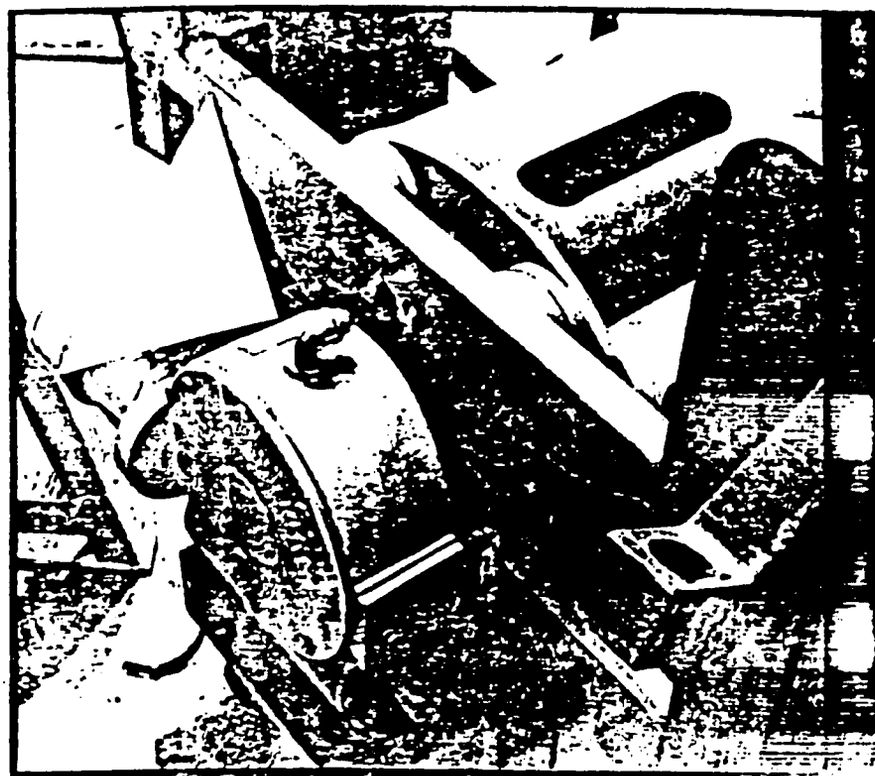
date 9-14-78

page

sheet 1 of 4

description TH60 DERRICK LUBRICATION CHART

drawing no.



1

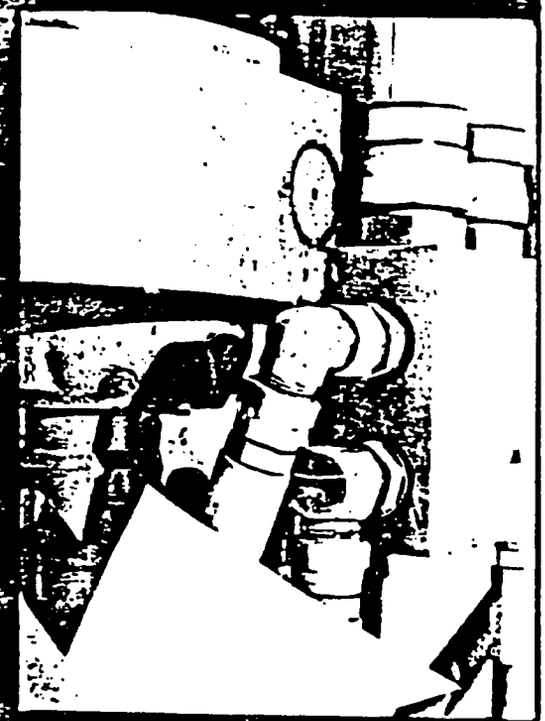
CARROUSEL DRIVE GEARBOX

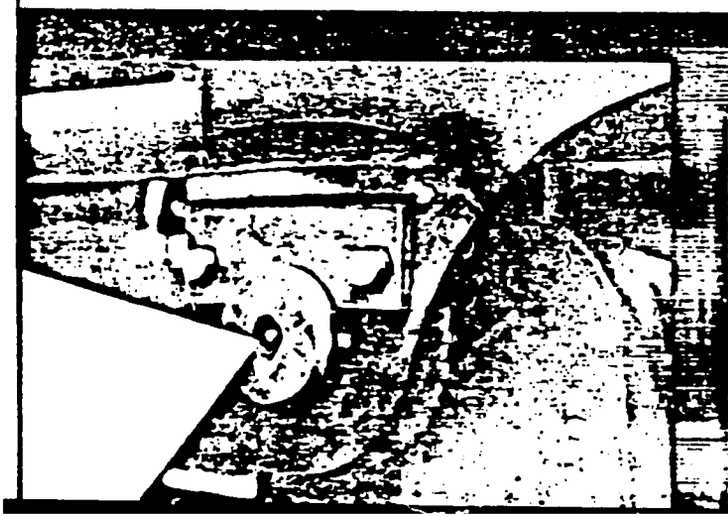
The lube level in the carrousel drive gearbox should be checked monthly. The derrick should be in the vertical or raised position when checking the lube level of this unit. The lube level should be filled to the 90° elbow with SAE 90W gear lube.

KING SWIVEL THRUST BEARING

2

The King Swivel bearing should be lubricated monthly under ordinary drilling conditions. Over-lubrication of this swivel may cause premature seal and bearing failure. A good-grade of petroleum-base grease should be used. It is not advisable to use grease containing Graphite or Moly for this application.





3

DERRICK HINGE PINS

The derrick hinge pins should be lubricated monthly.

CORRECTIVE MAINTENANCE

Finding the Leak

At first this discussion might seem absurd. After all, isn't a leak obvious? Certainly the effects of the leak are obvious . . . oil on machine, floors and product.

Remember that we must know the exact location of a leak before we can eliminate it. Anyone would be hard pressed to point immediately to the source of a leak on a machine which has oil over the top, sides, and dropping onto the floor. In fact, there might not even be a leak. The real cause might be an over-filled reservoir or a spill.

The first step then in locating leakage sources is to clean the area and watch. Focus on the four general areas where leaks can occur:

1. Fittings (commonly called connectors)
2. Hoses
3. Dynamic Seals
4. Static Seals

Most leaks occur at fittings but, too often, finding the fitting that is leaking is difficult because the fluid runs along the line and drips off at some other point. Always suspect the inaccessible connection; they are often installed carelessly because they are so hard to get to. Leaks in high pressure lines sometimes are difficult to pin-point because the fluid comes out as a mist. **(Use caution: high pressure leaks can cause personal injury.)**

Determine Cause of Leak

Once you find the location of a leak, the specific cause has to be determined before it can be corrected. A scratch in a fitting seat or a cut in a seal lip that is big enough to leak excessively can still be too small to find with the naked eye. A four power magnifying glass, used frequently to search for defects, will cut down on repeat repairs. What do you look for? The detailed information in the following sections will help you decide that. It will also help to correct leakage and prevent its reoccurrence.

THREADED FITTINGS

Types of Threads

There are two basic types of threaded joints. One has tapered thread that produces a metal-to-metal seal by wedging surfaces together as the pipe is screwed in. The other has straight threads and no wedging action, but has a rubberlike element that does the sealing.

Tapered threads have the advantage that an additional fraction of a turn usually will cure a slight leak. Their sealing ability, however, depends on how perfectly they are formed. In practice, threads are often carelessly machined and won't seal regardless of how much they are tightened. In such cases excessive torques are applied, and yielding or cracking results. Because of the frequency of such leaks there is a trend to quit using tapered pipe threads. Some companies limit their use to low pressure (below 500 psi) lines.

USA Standard (Symbol NPT)

The USA Standard pipe thread is tapered and shaped to engage mating threads on their flanks as shown in figure 1. This leaves a small spiral groove along their tips that must be closed with sealer (dope). The sealer also lubricates the threads and prevents galling.

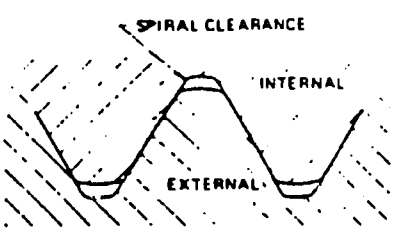


Figure 1 WRENCH TIGHT NPT THREAD

USA Standard Dryseal (Symbol NPTF)

These are very similar to NPT pipe threads, except they are shaped to make first contact at their roots and crests as shown in Figure 2. When the joint is pulled up tight with a wrench the thread crests are crushed until the thread flanks make full contact as shown in Figure 3. They don't have the built-in leakage path of the National thread but they can still leak due to machining imperfections. Dope should still be used on these threads for a lubricant but dope can't be expected to seal a poorly cut thread.

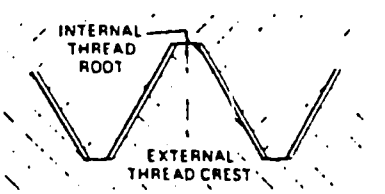


Figure 2 HAND TIGHT DRYSEAL NPTF

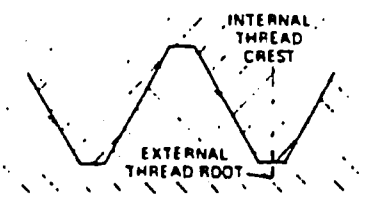


Figure 3 WRENCH TIGHT DRYSEAL NPTF

PETROLEUM BASE HYDRAULIC FLUIDS

The rapid increase in the use of more costly and sophisticated hydraulic equipment has put a greater demand on the quality of hydraulic oils required to provide satisfactory machine performances. There is also an increasing awareness on the part of the manufacturers that proper lubrication and preventive maintenance are vitally important to satisfactory machine performance.

The purpose of this bulletin is to provide guidelines for the selection of hydraulic fluids that will provide the efficiency and protection necessary for satisfactory operation of I.R. Cyclone drills.

FLUID REQUIREMENTS:

The oil qualities required by hydraulic system elements, and by operating conditions to which the oils are subjected, may be summarized as follows:

- Correct Viscosity
- High Viscosity Index
- High Film Strength and Proper Lubricity
- High Oxidation Resistance
- Good Water Separating Ability
- Good Anti-Rust Property
- Good Resistance to Foaming

Premium quality, anti-wear type hydraulic fluids, provide the most desirable balance of these qualities.

VISCOSITY:

Proper viscosity at operating temperature is probably the single most important property the fluid must possess. Viscosity affects efficiency and life. It is most commonly measured in Saybolt seconds (SSU or SUS), although SAE ratings are often encountered particularly in automotive type oils.

I.R. Cyclone recommends that a fluid have a Saybolt viscosity of not less than 100 SSU at operating temperature and preferably between 100 and 200 SSU at the operating temperature of the system when running continuously. This viscosity will provide a lubricating oil film of sufficient thickness to give maximum life.

Ambient temperatures affect system temperatures especially at the extremes, high or low. This must be considered in the selection of fluids with proper viscosity to meet different temperature conditions.

The following information is provided as a guide to the selection of fluids to meet different temperature conditions.

PRIMARY RECOMMENDATION: PREMIUM QUALITY ANTI–WEAR HYDRAULIC FLUIDS:

In I.R. Cyclone hydraulic systems where the oil serves as a hydraulic fluid only, premium quality, anti-wear type hydraulic oils are recommended. These products are balanced to protect the motors, maintain proper viscosity for extended periods of time and provide trouble free filtering capabilities.

Premium hydraulic oils with viscosity indexes of 95 or above will provide the temperature and viscosity ranges shown in Chart I.

CHART I

OPERATING TEMPERATURE RANGE	VISCOSITY RANGE AT OPERATING TEMPERATURE	VISCOSITY GRADE INDUSTRY IDENTIFICATION
84°F/122°F	200/100	150 SSU
107°F/140°F	200/100	225 SSU
116°F/150°F	200/100	300 SSU
130°F/165°F	200/100	450 SSU
145°F/182°F	200/100	600 SSU*

*Consult I. R. Cyclone before using this viscosity grade fluid.

Operating temperature is the main factor in determining which viscosity grade to specify. Fluids are identified by and can be ordered by viscosity grade. For example, in a system with operating temperatures up to 150°F the chart indicates 300 SSU premium grade anti-wear fluid will provide the required viscosity range. Be sure to include the complete description.

Must a Hydraulic System Leak?

Absolutely not!

The aircraft industry has virtually eliminated leaks in their hydraulic systems.

The mobile equipment industry has significantly reduced leakage in their machines and systems.

How has this been accomplished? One of the factors contributing to aircraft industry success was a switch to better fittings. The mobile equipment industry improved some of their designs by shifting from pipe thread to either straight thread or flange fittings. The most important factor, however, was DETERMINATION. Once committed, these industries followed through.

The Need to Stop Leaks

It has been estimated over a hundred million gallons of oil could be saved each year if external leaks from hydraulic machines and systems were eliminated. Add to this the cost of the labor for spill clean-up, re-filling of reservoirs, etc., and the total savings potential of no-leak systems could be tens of millions of dollars per year.

The HFI Yardstick

Is there a yardstick for checking a plant's hydraulic oil use?

Mobil Oil Corporation has developed the Hydraulic Fluid Index (HFI), comparing oil consumption to machine capacity. They discovered that each year the average plant used four times more hydraulic oil (HFI=4) than its machines actually hold. Ideally, the fluid should last almost indefinitely, and the HFI should be less than one. In practice, fluid is lost through leakage, line breaks and fluid changes. Any plant can cut its HFI (oil consumption) in half by developing skilled hydraulic maintenance men who can stop leaks before they occur, and control fluid contamination.

Hydraulics

PREVENTIVE MAINTENANCE

Before getting down to the specifics of finding and fixing leaks (corrective maintenance), let's consider another important part of leakage control—preventive maintenance.

Handling Repairs

Hydraulic components are precision devices. Careless handling of them or other parts of the system can result in malfunction or failure. To avoid creating problems when installing or repairing hydraulic components, follow these tips:

1. Clean away the dirt in and around equipment before taking apart lines and removing parts.
2. Cap off all disconnected lines and open ports.
3. Protect the overhaul area from grinding dust, machining chips, and wind driven dirt.
4. Work only on metal or hard finished bench tops, easy to keep clean.
5. Handle parts carefully to avoid nicks and burrs.
6. Use lint-free cloths to wipe parts.
7. Use smooth burr-less tools, especially when working with O-rings.
8. Lubricate all sliding parts during assembly.
9. Cover sharp grooves and threads with thimble or shim stock when installing O-rings and other seals.
10. Discard all used O-rings to avoid re-use.
11. Make certain that seals are of the right size and material.
12. Use only recommended replacement parts.
13. Examine all prematurely worn or malfunctioned parts for clues as to the cause of failure.
14. Test the overhauled device before reinstalling it, if possible. It's embarrassing as well as costly to remount a repaired component in the system, only to find that it leaks or doesn't work properly.

Fluid Temperature

Petroleum oils are used in most hydraulic applications to lubricate parts as well as transmit power. As oil temperature increases, however, the lubricating film thins out. The result is rubbing parts supported by the oil film move closer together; friction and wear increase; seal materials age more quickly, become stiff and hard, and may readily permit leakage.

To avoid trouble, industrial bulk oil temperature measured at the reservoir should be kept in the 100° to 130°F. range. Why? Localized hot spots—such as the one at the shaft seal—may be 100 degrees hotter than bulk oil temperature. As bulk oil temperature rises, hot spot temperatures rise an equal amount.

A thermometer on the end of a wire and placed in the res voir fill pipe will measure fluid temperature. Temperat stickers are available for attachment to the side of a reservoir suspected hot spot). Spots on the sticker permanently change color to indicate the maximum temperature.

If oil temperature in your operation exceeds 150°F., determine from your oil supplier whether you are using the correct grade and quality of oil. He may recommend a higher viscosity oil with anti-wear and anti-oxidation additives.

A quick test! **But approach this test carefully, because a severe burn is possible.** If you can't hold the palm of your hand on the pump inlet side of the reservoir when the system is running, the oil temperature is probably too hot.

The general rule for maximum reservoir temperature in mobile applications is ambient temperature plus 80 degrees. On a hot day, for example, of 90 degrees, bulk oil temperatures could go to 170°F. (90 + 80). Only premium oil loaded with additives is satisfactory here.

Nitrile (Buna N) seals can last almost indefinitely in 200°F. oil, but life is cut in half for every 25° temperature rise.

Fluid Temperature—°F.	Life—Hours
225	2000
250	1000
275	500

Fire resistant fluids with a water base require low temperature (130°F. maximum) to prevent excessive evaporation of water.

Fluid Contamination

"Keep it cool and keep it clean" is the secret of long fluid life. Contamination may be in the form of gas, liquid or solid; it may be chemically active or inert.

Common contaminants in hydraulic oil are:

Gas—air
Liquid—water and cutting oils
Solid—rust, chips and grit

It is usually easier to keep contaminants **out** of a system rather than remove them after they are in the system.

Bulk handling and the re-use of oil containers almost guarantee "new" oil will be dirty. Unless it comes from sealed quart containers, filter all "new" oil before adding it to your system.

Control solid particle contamination through filtration. Make it a practice to change all filters on a regular basis **before** they become clogged.

Fire resistant hydraulic fluids, whether water-based or non-water based, require a high standard of filtration within the circuit to maintain system reliability.

Seal Wear

In long life applications, a major cause of dynamic seal leakage is wear. Wear can also be the cause of static seal leakage. Shock, pressure surge and vibration cause static sealing surfaces to slide and separate in small amounts, where movement is measured in thousandths of an inch. Seal wear occurs and the seal eventually leaks. The rougher the sealing surfaces, the heavier the wear, and the sooner the leak occurs.

Measuring Surface Roughness

Inspectors use an electronic instrument called a profilometer to measure surface roughness and report the roughness height value in microinches (millionth of an inch). The smoother the surface, the smaller the reported value.

For static sealing, where surfaces to be sealed do not move relative to each other, commercial practice is to specify a 32 to 63 microinches (abbreviated μ in.). As long as surface separation or seal movement does not occur, satisfactory sealing is possible on surfaces with light circular tool marks up to 100. But no matter how smooth the overall surface, a nick, gouge, longitudinal scratch or spiral tool mark provides a leak path.

For dynamic sealing, the surface moving relative to the seal requires a nominal 16 microinch finish.

As a guide, the surface roughness produced by common production methods is:

Production	Roughness Height
Milling	32—250
Die Casting	32— 63
Boring, Turning	8—250
Grinding	4— 63
Polishing	4— 16

Cut Through the Jungle of Fluid Lines

If your system is a jungle of fluid lines and connections with components almost inaccessible, the odds of controlling leakage are against you.

Simplify the hydraulic system whenever possible. The fewer the connections, the fewer the possible sources of leaks. Consider back-mounting your valves, with all pipe connections made permanently to a mounting plate. Even better is the use of manifolds, which provide interconnections between valves and eliminate a lot of external plumbing.

Tubing Clamps

Shock, pressure surge, and vibration will flex metal tubing. This flexing will fatigue the tubing, particularly around line fittings. The consequences are cracked fluid lines. A well designed fluid power system will include tubing clamps to minimize shock and vibration. All tubes should be clamped on both sides of a bend, as close to the bend radius as possible.

Manufacturers generally recommended spacing between clamps as shown:

Tubing Diameter OD—in.	Distance Between Clamps—Feet
3/16—3/8	3
1/2—7/8	5
1—1 1/4	7