REPORT ON FISH HANDLING AND REFRIGERATION IN TONGA
for the
TONGA COOPERATIVE FEDERATION
and
FRIENDLY ISLANDS
MARKETING COOPERATIVE LTD.

AID Contract No. 879 G-1013

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TABLE OF CONTENTS

APPENDICES

INTRODUCTION

This report represents the findings of the refrigeration consultant who spent three weeks in October-November 1985, assessing Tonga's fish handling and marketing conditions for the AID/ACDI assisted Tonga Cooperative Federation (TCF) and the Friendly Islands Marketing Cooperative, Ltd.

The scope of work for this assignment was as follows:

1) Review and assess the overall frozen products handling procedures and needs of TCF and FIMCO in Vava'u and Tongatapu. This should include refrigeration and accessories needed for the handling, storage and marketing of fish, meat and other perishable products.

2) Recommend specific types of refrigeration equipment and accessories appropriate for TCF and FIMCO, bearing in mind the source and origin procurement requirements of the U.S. government and the available budget.

3) Prepare specifications for the needed equipment in sufficient detail and form to allow for international procurement without additional technical assistance.

4) Prepare a brief report detailing work accomplished; problems encountered in the handling, storage, processing and marketing; possible solutions and recommendations for future activities in the marketing field.

II. SUMMARY OF FISH HANDLING, REFRIGERATION AND MARKETING RECOMMENDATIONS

Good handling practices for fish on fishing boats as well as of all frozen products must be established prior to beginning export. A number of the fish-handling practices observed by the consultant during his stay in Tonga should be improved in order to obtain a high quality product suitable for export. The extra effort involved in these improvements will, in most cases, be minimal, inexpensive and easy to follow but they are very important if uniform, export-quality fish products are to be obtained.

On board fish handling:

- Fish must be gutted immediately after catch to retard spoilage, particularly if it is to be frozen later.

- Fish must be gutted clean (if they are gutted). This is particularly true in the tropics.

- Fish should be gutted through a cut straight down the middle of the belly, not in the side as this might adversely influence the price in an export market (fillets might be ragged and uneven).

- Ideally, fish should be iced in such a way that it is covered entirely with crushed ice until it is sold or transferred to a freezer. This assures quality of the catch and applies both onboard and ashore. Unmelted ice can be used on the next trip providing it is kept clean.

- Fish should be stored in ice in an insulated box with a bottom drain to assure they are not lying in water but are washed continuously by melting ice to reduce spoilage.

- Ice boxes should have an easy to clean surface, be well insulated, have a bottom drain and be placed in the shade.

- To chill 1 kg of fish from 16° C to 0° C, 0.2 kg ice is used. If the fish is left on board before it is put in the ice box, the temperature will rise. For example, to chill the fish from 32° C to 0° C will take 0.4 kg ice or twice as much as if the fish had been iced immediately after catch. Thus, it is cheaper to put the fish inside the box as soon as it is caught rather than allowing it to warm on the deck and then insert it.

- To keep the ice box cold once the fish has been chilled takes approximately 0.5 kg of ice per hour. This does not depend on how much fish is in the box but is based on the condition that the box (1 x 1 x 0.8m) is well-insulated and is placed in the shade. If it is left in the sun, ice consumption could be twice as high, i.e., 1 kg per hour.

- The following formula can be used to estimate how much ice is needed to chill and hold 100 kg of fish for one day:

Chilling of fish	100 x 0.2	20 kg
Holding for 24 hours	24 x 0.5	12 kg
		32 kg

This figure represents absolute minimal ice use.

- There should always be ample ice left to cover the fish at the end of the trip.

Handling in the Freezer Plant

- Fish should be kept iced until it enters the freezer. This is true for both whole fish and for fillets.

- No excess water should enter the freezers.

- Only blast freezers should be used to freeze fish; a storage freezer is inefficient and causes dehydration and weight loss as well as increased drip loss when the fish is thawed if the freezing process is slow.

- Fish being frozen should be swept by maximum airflow to utilize wind chill factor for faster freezing.

- As soon as the fish has been frozen through the core (freezing times may be determined by measuring core temperatures until experience is gained), it should be moved from blast freezer to storage freezer. This practice minimizes freezer burn and increases plant efficiency.

- Temperature in a storage freezer should be kept constant, preferably around minus 22° C and never above minus 10° C. Fluctuations in temperature increase dehydration, weight loss and freezer burn of product.

- Products being stored for a long time should be alone in a freezer and not mixed with others which require opening the freezer many times a day.

- As much fish as possible should be consolidated in as few freezers as possible.

- Storage freezer doors should be kept shut as much as possible.

- Doors should be fitted with a heavy plastic strip curtain to reduce the flow of hot air into the freezers.

- Products in freezers should lie on pallets, not directly on the floor. Pallets or similar material ensure air circulation under the product and avoid hot spots. (See Annex 5 "Cost of Freezing, Holding and Ice Making").

Glazing

- It is recommended that the frozen product be dipped in chilled fresh water to form a protective glaze of ice on the surface. It is especially important to protect expensive products such as lobster tails this way. Double dip glazing, where a product is dipped again after hardening of the first glaze, is considered necessary if the product is to be stored for a long time.

- Besides improving product quality by minimizing dehydration and freezer burn, glazing also adds some weight to the product. In many cases, purchasers expect a glaze on the product and base their prices on a certain percentage of the product weight being glaze. It can, therefore, be very profitable to add 5-8% to the weight by glazing.

Fish Marketing

- By building more and larger boats, the Tongan fishing fleet size will be increased and larger catches will result.

- Expansion of the fishing industry will mean that certain high value species will be exported while less desirable ones remain in Tonga. The Tongan market will not be able to absorb all fish caught in the future nor pay world market prices for high value species.

- Fish consumption in Tonga could be increased by:

  - Pricing fish competitively with other food products.

  - Distributing fish more widely to villages currently without easy access to seafoods. Freezers are found in more and more small retail stores and frozen fish and frozen sipi could be distributed together.

  - In major population areas such as Nuku'Alofa and Neiofu, fish consumption might be increased by opening up sanitary retail stores specializing in seafoods. A nice display and availability of highest quality products should increase seafoods sales, especially to affluent Tongans and to foreigners living there.

  - Seafood sales to cruise liners and cargo vessels calling into Tonga could be increased. Assessing demand for species and quantities and assuring consistent quality and availability could persuade these customers to choose Tonga as a point for purchasing seafood supplies.

Overseas markets, particularly in Hawaii where high quality fresh seafoods are a tradition, should be explored. Even though airfreight costs might be high, certain Tongan seafoods could be sold competitively. This is especially true during times when local Hawaiian products are out of season or the local fishing fleet is hampered by bad weather.

It is also feasible for certain species to be air shipped fresh to U.S. west coast cities where seafood restaurants and ethnic groups demand certain species with little regard for price. Development of those markets might prove costly and would, without doubt, demand a steady supply once established.

Frozen, high value seafoods like lobster tails, can bring attractive prices on the international market. They are sold in batches through brokers and in order to obtain the best prices, they must be prepared and packed in accordance with the demands of the world market.

III. REFRIGERATION NEEDS ASSESSMENT

John Kreag provided the consultant with a comprehensive overview of TCF's fish freezing and marketing situation and introduced him to several qualified technicians possessing knowledge of local availability of parts and services.

The consultant visited the freezing and cold storage facilities at the government market in Nuku'alofa to assess the level of maintenance and meet the personnel. (See Annex 1 - "Survey and Evaluation of Refrigeration Equipment in the Government Market, Nuku'alofa"). TCF utilizes the facility and John Kreag felt it important to document the current condition of the plant.

At the fisheries freezing facility in Sopu, he met Siotame Taunaholo, a Tongan very well trained in refrigeration on the practical level (two years in Japan and five months on FAO training for refrigeration engineers), who is establishing his own refrigeration installation and repair business and who could be very useful for TCF/FIMCO's operations when they get their own freezers.

At the end of the first week, the consultant went to Vava'u to spend a couple of days observing TCF's fishery operation. He got a first hand impression of the operation with respect to how fish are brought in from the fishing boats and frozen then stored and sold retail (see Annex 2 for a survey of the refrigeration plant, "TCF Fisheries Operations at Neiafu, Vava'u").

He also visited a fishing boat building facility in Vava'u. Based upon information about boat building activities, the size and number of those produced, he was able to forecast the future importance of an efficient fish handling and marketing system. Future expansion of the Tongan fishing fleet will without doubt, increase fish production to a degree that will necessitate export of certain high value species while less desirable ones remain for sale on the Tongan market.

Based upon his field observations and talks with John Kreag, he made the calculations necessary for a basis of design for the cooling/freezing equipment needed. As a guideline for energy costs for different operations, see Annex 3, "Costs of Freezing, Holding and Icemaking."

He discussed different refrigeration options with the concerned TCF staff and the unit types he advised them on are described in Annex 4, "Recommended Walk-in Cooler/Freezer Units".

Annex 5 contains specifications and a brief draft "Invitation to Bid". These were prepared so that the bidder is left with a high degree of freedom to choose components. This

permits the creation of the best system with as many common components as possible. The essential criteria, however, are laid down in the specifications.

The specifications have been divided into refrigeration equipment and walk-in boxes. This is to allow local companies capable of making only the boxes to have an opportunity to participate in the bidding. Because of the high cost of transportation from the U.S. for these boxes, it may be possible to obtain locally manufactured equipment at a favorable price If this can be done, some expertise will be established in Tonga.

From the brief time he stayed in Tonga, the consultant had a very positive impression of TCF and its work in the fishing and wholesale fields. He feels am confident that over the next couple of years there will be a need for more freezing equipment. What has so far been specified are just a few basic units, simple and inexpensive to operate, but the potential to duplicate, move and expand these locally has been kept in mind.

It is recommended that the technical aspects of submitted bids be checked by the consultant in order to ensure their compliance with TCF/FIMCO specifications and intentions.

ANNEX A

SURVEY AND EVALUATION OF REFRIGERATION EQUIPMENT AT GOVERNMENT MARKET, NUKU'ALOFA

After spending time inspecting the system, the consultant reported a few examples of poor engineering and maintenance which should be corrected. The cost of the changes would be recovered recovered by better efficiency, higher capacity and longer lifetime for the refrigeration equipment.

Freezer Boxes:

- All safety controls should be checked for performance.
- Pump down solonoid valves should be checked for function.
- Suction accumulator should be installed in compressor suction lines to prevent liquid hammer and damage to compressor.
- Suction regulator valves should be omitted, if possible, as they reduce system efficiency.
- Electric heaters should be placed in the freezer box for electric defrosting of evaporator. If this is not possible, new evaporators with larger fin spacing (minimum 6mm) and electric defrost should be installed. This will allow for more efficient operation at lower power consumption.
- Electric defrost should be operated by timer.
- Alternatively, procedure for daily water defrost should be maintained, but problem caused by calcium deposits on evaporator will arise.
- It should be noted that the freezer boxes are not intended to do any freezing of unfrozen products but are intended only for holding with limited product subcooling capacity. Furthermore, the inside of freezer boxes should be kept dry (not defrosted with water from inside or loaded with wet fish) in order for them to perform efficiently.

Ice-Makers:

- Bypassed safety controls on unit compressor should be wired correctly.

- Ice-maker tube system might be repaired, but it is likely to be more expensive than replacing it with a more efficient modern drum-type ice-machine with a capacity matching existing compressors. Units should be of a type that can produce ice from the special hard water available.

- It is necessary for efficient operation of the government market refrigeration equipment that a skilled person with training in basic refrigeration skills be in charge of and responsible for maintenance and operations.

Ice-Making Equipment in Government Market

Presently, the market has two ice-makers manufactured by Liquid Carbonic, USA. Each has its own condensing unit and may be run independently. The ice-makers are in bad condition and will require quite a bit of work to be operationable. It is presumed that the condensing units (compressor with motor, condenser, receiver etc.) are in mechanically sound condition. One of the existing ice makers may, therefore, be repaired using parts cannibalized from the other. Even if it has problems operating on city water, it would be possible to keep it going, at least on low capacity.

The other condensing unit could then be hooked up to a new, drum-type ice maker with proper water treatment equipment such as an automatic brine dosing unit. (Existing water treatment consists of a cylinder, where water is forced over permanent magnets.)

For a long-term solution, a new drum-type ice-maker in which ice is scraped off the drum surface (drum rotating: ice scraped off outside - ATLAS Manufacturers or inside: knife rotating - North Star, Howe, or Matal Manufacturers) could be purchased.

ANNEX B

TCF OPERATIONS AT NEIAFU, VAVA'U

To get a general idea of needs for freezing, holding and retailing of fish, some time was spent observing the fish buying, storing and selling procedures in Vava'u. The operation there seemed to be typical of other places in Tonga.

After seeing the Neiafu operation, the consultant was impressed by the quality of the products, both fresh and frozen as well as with the efficient utilization of existing facilities. When buying and selling fish, almost every inch of floor space is used and crowded, especially in the mornings and it was impossible for him to find any desk space. The only table available in the office functions as a desk, a storage area for packaging material and tools and as a stock and display area for fisheries supplies.

There is a definite need for more retail space.

Regarding the freezer and ice plant, it was noticed that the plant operated reasonably well and seemed relatively well maintained and clean.

Two freezer rooms, Nos. 5 and 6, are the ones best suited for freezing. They have a fin-spacing of 8-10mm which is acceptable for freezing. Freezer efficiency can be increased by guiding the flow of of cold air better over the fish and assuring that no air short circuits from the front to the back of the air cooler. Placement of plywood or sheet metal air guides was explained to Bob.

Freezer No. 1 may also be used for freezing. The compressor is 7.5 KW, but the fin-spacing on the air cooler is only 4-5mm, which means that air flow and heat transfer will be very limited when freezing wet fish. Frost blocks the air flow through the air cooler and defrosting must take place often. This freezer will be best utilized for freezing packaged products like fillets or freezing very large fish. As a steep ramp leads to this freezer, it is difficult to load carts into it. It might be best to furnish it with stationary shelves for large fish.

Three freezer rooms, Nos. 2,3 and 4 are intended only for storing products, for very limited freezing or for sub-cooling. The brine type block ice freezers seemed to work satisfactorily, except for one which was out of commission due to a leak. The capacity, however, could be improved. First, the compressor should be kept running, thereby making colder brine, even if ice

blocks are already frozen and waiting to be discharged. Also, during loading/unloading the compressor should be kept running and a small pump or agitator should be installed in the brine tank to assure some circulation of the brine. This would increase efficiency and motor size need not be more than 0.25 Hp. Ice plant capacity should be approximately 1-1.2 ton per 24 hours.

To assure better performance and longer lifetime, the following modifications are recommended:

- Suction accumulators installed on compressors 1, 2 and 3
- Solonoid valves should be installed in liquid line on compressors 1, 2, 3 and 4.
- Ice maker should be repaired.
- Regular maintenance should be performed to keep equipment in good running order.

ANNEX C

COST OF FREEZING, HOLDING AND ICE MAKING

Freezing

Power consumption for freezing is approximately 0.1- 0.15 per kg of product to be frozen. This means that if power price is 25 cents/KWH then it will cost 2.5-4 cents per kg in direct power consumption to freeze fish.

Ice-Making

To make block ice in a brine tank, power consumption will be approximately 0.05-0.08 KWH/kg, meaning power for freezing will cost 1.25-2 cents per kg (15kg block would cost approximately 20 cents). To make scale ice, power consumption will be approximately 0.07-0.1 KWH/kg, costing about 1.75-2.5 cents per kg.

Holding at Minus 20^{o}C:

Approximate heat loss through walls is 40 kcal/h per m^3, not counting loading and unloading. This means a freezer with inside dimensions of 3 x 3 x 3m (approximately 30 m^3) and holding around 15 ton, will absorb approximately 1.5-2 KWH/hour. This adds up to 36-48 KWH/day and costs $9-12/day or 30-45 cents/$m^3$/day. Cost is highest for small freezers as the surface is less in relation to volume. Energy cost is not affected by whether of not the freezer is full (500-800 kg per m^3) or empty.

ANNEX D

RECOMMENDED WALK-IN COOLER/FREEZING UNITS

Based on discussions and observations during his stay in Tonga, the consultant suggests procurement of the following types of coolers and freezers.

Item I: Walk-In Storage/Display Freezer

This unit is intended for both retail fish stores and the wholesale market. Size is based on holding 60 x 20 kg cases of Sipi and 30 of butter at -20^0C. Internal volume should be $5m^3$ and outside dimensions 2x2x4m. The front of the unit is furnished with a door and a display window. Cost of operation is approximately $5.50/day. Two units will be needed.

Item II: Walk-In Cooler For Wholesale Store

Same dimensions as for Item I, able to hold approximately 150 cases of beer or pop at 2^0C. Unit is furnished with access door on the side and has a double glass door on the front for display and self-service. Cost of operation is around $4.75/day.

Item III: Walk-In Storage Freezer For Fish

This unit is intended for installation at the wholesale warehouse. Capacity is based on holding 10 tons of fish at -20^0C. Internal volume should be $29m^3$ and outside dimensions 3.4x4.4x2.8m. Cost of operation will be about $11.30/day.

Item IV: Large Walk-In Storage Freezer For Wholesale Market

This unit is intended to hold 700 x 20 kg cases of Sipi and 250 x 20 kg cases of butter at -20^0 C. Inside volume is $48m^3$ and outside dimensions 4.4x5.4x2.8m with cost of operation at around $18.20/day.

Item V: Combined Walk-In Storage Freezer/Product Freezing Unit (To be installed on 'Eua Island)

The unit should hold 5 tons of frozen fish and ice blocks plus allow for freezing 300 kg fish and 200 kg ice blocks every 24 hours. If more freezing capacity is needed, a separate ice machine can be installed. Unit is designed for power supply 24 hours/day and air cooler is designed for freezing products loaded on racks in front of it. Inside dimension is $22m^3$ and outside is 3.4x3.4x2.0m. Cost of operation will be approximately $34.00/day when freezing and holding or $10.00/day holding only.

The units are intended to be built in modules to allow flexibility and ease in assembly and disassembly should they need to be moved. The specifications for the freezers do not call for equipment more sophisticated than can be manufactured in Tonga, giving local companies a chance to gain experience in this kind of work and making it possible to rely on local suppliers for future jobs.

Electric Power in 'Eua

The Tonga Power Supply Board gave the consultant the following information about power in 'Eua.

Currently, they have 2x75 kVA generators but have a load for only one. At the end of next year they expect to run lines to the airport and have 24 hour operation. They now have power according to the following schedule.

4 a.m. - 11 a.m.	7 hours
12 p.m. - 4 p.m.	4 hours
6 p.m. - 11 p.m.	5 hours
	16 hours/day

It is suggested that TCF/FIMCO confine themselves to equipment for 24 hour/day power supply and accept lower freezing capacity (approximately 2/3 or 30 kg/24 hours) until power is available 24 hours per day.

ANNEX E

INVITATION TO BID

Under the USAID/ACDI program, monies have been allocated to supply the following refrigeration and storage equipment to the Kingdom of Tonga.

When selecting equipment, emphasis will be laid on low energy consumption (as power cost is approximately $.25/kwh) and on simplicity of operation. Another factor will be that, wherever feasible, equipment manufactured in the USA should be used. Exceptions may be dictated by limited availability of spare parts in the area and through traditional suppliers in Tonga, New Zealand and Eastern Australia.

Local labor for handling and erecting, etc. is available at approximately $1/hour. Skilled craftsmen such as welders, fitters, etc., educated overseas, are available at about $30/hour.

This invitation to bid is divided into two parts: refrigeration equipment and walk-in units.

Bid Terms

Bids must comply with specifications listed here and only minor adjustments are allowed without consulting the purchaser or his technical consultant.

The purchaser will be: Agricultural Cooperative Development International
1012 14th Street, N.W., Suite 600
Washington, D.C. 20005
Telex: 160923 AGCODEV
Telephone: (202) 638-4661

Bids should be in hands of: Roger G. Heller

No later than: March 1, 1986

Purchaser's Technical Consultant: Lars Matthiesen
4215 21st Avenue West
Seattle, Washington 98199
206-285-0904
206-782-8960

Vendor will be selected no later than: April 1, 1986, for delivery of equipment FOB U.S. West Coast, New Zealand or Australian port no later than: May 1, 1986.

Purchaser reserves the right to accept any or none of the bids submitted.

Bid must contain prices, terms, technical information such as compressor swept volume, power consumption, refrigerant, condensing surface area, air cooler fin spacing, air flow, material dimension sketches and shipping weights and volumes.

The Purchaser will:

- Supply shipping, importation and duty charges from FOB destination.
- Deliver equipment to installation site.
- Keep merchandise insured from FOB delivery destination.
- Provide power at site of installation (for installation and for hook up of refrigeration equipment).
- Provide foundation (concrete slab) with sufficient venting to avoid frost heave.
- Provide building or shelter for freezer box and compressor units.
- Provide adequate outdoor air for air-cooled condensers (not including fans).
- Provide assistance in contacting possible local sub-contractors.
- Apply for necessary local licenses and permits.

Refrigeration Equipment for Walk-in Units

Further information regarding heat load might be gathered from walk-in unit specifications and from the general specifications enclosed.

Vendor must supply:

Item 1-Small walk-in storage freezer:

Two sets of refrigeration equipment for walk-in freezer with internal volume approximately $5M^3$ ($176.5F^3$) and dimensions inside approximately 1.6x1.6x2m (5'4"x5'4"x6'8"). Door of freezer could be opened up to 10 times per hour during 10 hour day for loading and unloading. Sub-cooling of 300 kgs fish/25 hours from -10^oC to -20^oC should be allowed for.

Item 2-Small walk-in cooler:

One set of refrigeration equipment for walk-in cooler with dimensions similar to above. Double glass doors on front may be opened up to 20 times/hour during 10 hour day. Sub-cooling for 100 cases of pop from 25°C (77°F) to 2°C (36°F)/24 hours should be allowed for.

Item 3-Walk-in storage freezer for fish:

One set of refrigeration equipment for walk-in freezer with internal volume approximately 29M^3 (1025ft^3) and dimensions inside approximately 3x4x2.4M (10x13x8ft). Door of freezer might be opened 5 times/hour. Subcooling of 1,000 kgs of fish from -10°C to -20°C (-14°F to - 4°F) per 24 hours will be allowed for.

Item 4-Large walk-in storage freezer:

One set of refrigeration equipment for walk-in freezer with internal volume approximately 48M^3 (1695ft^3) and dimensions inside 4x5x2.4M (13x16x8ft). Door may be opened 5 times/hour and sub-cooling of 2,000 kg of meat from -10°C (14°F) to -20°C (-4°F) will be allowed for.

Item 5-Combined walk-in storage freezer/product freezing unit (To be installed on 'Eua Island):

One set of refrigeration equipment for walk-in freezer with internal volume approximately 21.6M^3 (762ft^3) and dimensions inside around 3x3x2.4M (10x10x8ft). Door of freezer might be opened 5 times/hour and the freezer should have the ability to blast freeze 300 kg of fish from 15°C (59°F) to -20°C (-4°F) + 200 kg water in aluminum pans from 25°C (77°F) to -20°C (-4°F) every 24 hours. Fish might be wet and fin spacing in aircooler should be at least 8mm (5/16") to allow efficient operation. Air flow must be sufficient to freeze a 100mm (4") thick fish in less than 10 hours. Products will be batch-loaded twice a day. Air cooler should be designed to allow a sufficient volume of a product to be placed on racks in the air stream in front of it.

Walk-In Units

Vendor must supply:

Item 6-Small walk-in storage freezer:

Two walk-in units with a 4.5-5.5M^3 internal volume (159-194ft^3) and a maximum outside height of 2.5M (98") Inside dimensions should be about 1.6x1.6x2M (5'4"x5'4" x6'8"); the door on the front of the unit should measure about 80x200cm (31"x78") and the display window approximately 60x140cm (24"x55").

The front should be covered with stainless steel except for the display window which should be a minimum of 3 layers of glass like Ardco Sta-Clear 3 or similar material.

Item 7-Small walk-in cooler:

Walk-in cooler with internal volume 4.5-5.5M^3 (159-194ft^3) and a maximum outside height of 2.5 m (98") and inside dimensions approximately 1.6x1.6x2m (5'4"x5'4"x6'8"). Unit front should be furnished with double display doors of double-glazed Ardco or similar material to run full width of unit and be about 140 cm (55") tall. Side of unit to be furnished with loading door approximately 80x200cm (31"x78")

Item 8-Walk-in storage freezer for fish:

A walk-in freezer unit with an internal volume of 29M^3 +/-2M^3 (1025ft^3 +/-70ft^3) and dimensions approximately 3x4x2.4m (10x13x 8ft). 3M on the side of the unit should be furnished with an 80x200 cm loading door (31"x78").

Item 9-Large walk-in storage freezer:

A walk-in freezer unit with an internal volume of 48M^3 +/-3M^3 (1695F^3 +/-105F^3) and dimensions measuring approximately 4x5x2.4M (13x16x8ft) and 4M inside the unit to be furnished with a loading door approximately 80x200cm (31"x78").

Item 10-Combined walk-in storage freezer/product freezing unit (to be installed on 'Eua Island)

One walk-in freezer unit with internal volume 21.6 M^3 +/-1M^3 (762ft^3 +/-35ft^3) and dimensions approximately 3x3x2.4m (10x10x8ft). One side to be furnished with a loading door around 80x200cm (31"x78").

GENERAL SPECIFICATIONS

- Equipment for Nuku'alofa and 'Eua Island, Kingdom of Tonga should be designed for high ambient temperatures of 30°C (86°F) and an average daily temperature of 25°C (77°F). Equipment should be located out of direct sunshine.

- Power supply: 1x240V and 3x415V 50Hz

- Equipment is to be quoted FOB US west coast or Australian or New Zealand ports.

- Electric and mechanical equipment does not have to comply with any specific code but should be built to the normal standard of refrigeration equipment in the vendor's country.

- The compressors must be fitted with an automatic stop for low suction pressure, high discharge pressure and low oil pressure (if pressure lubricated-type). There must be access valves on the units for measuring suction and discharge pressures.

- Condensers are to be air cooled and have ample dimensions to reduce power consumption.

- Refrigerant should be R12, R22 or R502.

- Equipment to be designed to fulfill its capacity by running less than 20 hours per day.

- First charge of refrigerant and oil to be included in delivery.

Operation temperatures of walk-in freezers should be -20°C (-4°F). Temperatures may exceed that only immediately after loading with a warm product.

- Operation temperature for walk-in cooler should be maximum 5°C (41°F) and minimum 0°C (32°F).

- Air cooling must be forced air type with automatic electric defrost controlled by timer. Fin spacing must be minimum 6mm (1/4") in the walk-in freezers (Items 1-4) and minimum 8mm (5/16") in Item 5.

- Refrigeration equipment must be supplied with necessary motor starters, controls, timers, etc. Motor starters may be direct on-line type.

- Motor starters should be of Cutler-Hammer manufacture.

- Compressor controls should be Danfoss manufacture.

- Condensing unit to be furnished with a solenoid valve in liquid line for shut-off during defrost.

- Flare-connected filter-drier to be installed in liquid line.

- Suction accumulator to be installed in compressor suction line.

- Compressor to be furnished with equipment to assure automatic oil return to crankcase.

- Connection piping for mounting of condensing unit up to 5M (15 feet) from walk in unit should be included.

- Plumbing for defrost water, including pea-trap and necessary heating wire, to be included.

- As many of the components as is possible should be the same for the different units in order to minimize the need for a large spare parts inventory.

- Walk-in units to be pre-fabricated or made from elements that are easy to assemble and disassemble on-site. The walls and ceiling inside and out must be strong and durable to withstand normal use and local environmental conditions. The inside must be coated with non-corrosive metal or plastic and with non-toxic white water-resistant coating adhering firmly to the walls under all conditions. Outside to have white weather-resistant coating or paint, protecting the wall material. Design must allow easy cleaning of units.

- Preferable, the roof should be self-supporting but inside support is permissible.

- The units must be furnished with an insulated floor.

- The floor must be furnished with a water tight wearing surface of aluminum or galvanized steel strong enough to withstand 1500kg/M^2 (300lbs/ft^2). The wearing surface must be joined to the walls by a watertight sealant allowing thermal expansion.

- The elements of the walk-in units must be sealed air tight towards each other.

- The elements must have a heat transfer factor for roof, wall, doors and floor not to exceed 0.15Kcal/M^2 H^oC (0.031 BTU/FT^2H^oF) as a total average for the unit.

- Polyurethane or styrofoam insulation is preferred. If polyurethane is used, it must be of an oil resistant type.

- All walk-in units are to be equipped with sufficient working light (low heat radiation type) and an outside switch.

- Doors or door frames on the units are to be fitted with heat wire to avoid freeze-up of door gasket.

- Door to be fitted with gasket for air tight seal.

- The door must have a positive latch with inside safety release.

- Inside of doorway should be installed a heavy plastic strip curtain to minimize air flow when the door is open.

- Temperatures in the walk-in units should be controlled by a Danfoss room thermostat fitted on the units next to the access door.

- Doors and door frames should have a surface of stainless steel with a sanitary finish.

- A 75mm (3") dial thermometer must be fitted on front of unit indicating centigrade degrees.

- Installation and commissioning on site must be included in prices.

- Equipment must be warranted by vendor to fulfill performance as requested in specifications, and defects in materials and workmanship from a minimum of one year from date of trial run.

- Warranty should cover possible modifications if equipment fails to meet its requested performance.

- Defective parts covered by warranty should be replaced or repaired the fastest way possible at no cost to purchaser except labor.

- Vendor must supply 2 sets of refrigerant diagrams, wiring diagrams and a parts list of vital components.