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# SAMARA CABLE COMPANY
# POLLUTION-PREVENTION ASSESSMENT REPORT

An In-Plant Environmental Assessment for Low-Cost/No-Cost
Pollution-Prevention and Abatement Measures

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Submitted by:
Chemonics International Inc.

with the cooperation of:
The Russian Engineering Academy, Volga Department
Samara, Russia

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Environmental Action Programme Support Project
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## LIST OF ABBREVIATIONS

| | |
|---|---|
| $CO_2$ | Carbon dioxide |
| Cu | Copper |
| HEPA | High efficiency particulate air filter |
| kWh | Kilowatt hours |
| O&M | Operation and maintenance |
| Recom. | Recommendation |
| ROI | Return on investment |
| Ru/yr | Rubles per year |
| TER | Technical effectiveness rating |

# PREFACE

This report documents the results and recommendations of a pollution-prevention assessment conducted at the Samara Cable Company, with its cooperation and permission.

The EAPS Project is a part of the environmental component of the Samara Regional Investment Initiative, a collaborative effort among the U.S. and Russian governments, regional authorities, and private sector entities. The overall purpose of the initiative is to improve the investment environment and business climate for sustainable economic growth in selected regions of Russia.

USAID/Russia selected the EAPS project to carry out the initiative's environmental component, which concentrates on activities to promote identification and implementation of no-cost/low-cost measures to improve environmental and economic performance of Samara enterprises. EAPS emphasizes that enterprises can join sound environmental practices with sound business practices and incur little or no financial burden.

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- Lubov Y. Kirichenko, general director, Industroyprojekt Institute, Samara, Russia
- Vladimir I. Skriagin, leading engineer, Ecology Protection Department, Samara Bearing Plant, Samara, Russia
- Russian Engineering Academy, Volga Department, Samara, Russia

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# EXECUTIVE SUMMARY

This report documents the recommendations of a pollution-prevention assessment at the Samara Cable Company's small cable-manufacturing operation. The assessment aimed to provide a rapid evaluation of the pollution problems in this part of the plant, and devised recommendations for no-cost/low-cost measures to improve environmental performance with concomitant economic benefits.

The small cable-manufacturing shop was selected for the assessment based on Samara Cable management's recommendation. Time and budget constraints limited this assessment to only a partial identification of environmental issues and analysis of cost-effective recommendations. The EAPS consultants discussed the pollution-abatement recommendations with senior-level management in an exit interview. Although there was general agreement on the environmental priorities and recommendations, the company needs to do further work to refine these recommendations and implement them practically.

This report prioritizes the recommendations in terms of investment requirements (not all recommendations are no-cost) and technical effectiveness (i.e., probability of success in abating a pollution problem or achieving economic benefits). The company should view these recommendations as a starting point in developing an environmental management plan for the part of the plant that has been assessed. The EAPS team recommends that Samara Cable apply the step-by-step methodology in the EAPS guide, "In-Plant Environmental Assessment Sourcebook: A Guide to Pollution Prevention Planning."

# SAMARA CABLE COMPANY POLLUTION-PREVENTION ASSESSMENT REPORT

## A. The In-Plant Assessment

The in-plant assessment consisted of the following:

1. *Pre-assessment.* This step involved collecting general information about the operations of the facility, the specific shop area chosen for the assessment, and waste issues. The information collected during this phase was based on a pre-assessment questionnaire (Annex A), provided to the enterprise at the start of the program; and two meetings with technical experts the plant assigned to the assessment team.

2. *One and one-half day walk-through of the operations.* EAPS consultants focused on specific areas of the shop to evaluate waste problems and pollution issues. They conducted interviews with shop operating personnel and local management.

3. *Exit interview with the plant technical experts.* This interview entailed a review of preliminary findings and recommendations. Pollution-prevention recommendations were further refined.

4. *Exit interview with senior management.* The assessment team presented its recommendations.

The assessment showed three pollution media that require an environmental management action plan: air, water, and solid waste. As stated above, because of budget and time restrictions, not all low-cost/no-cost pollution-prevention opportunities were identified or assessed for their potential benefits. However, the company can use principles outlined in this report to develop a more thorough management plan. The potential savings from the low-cost/no-cost pollution prevention-abatement measures is estimated to total 333,040 Ru/yr. The company will need to make some investment to assess the technical feasibility of the main recommendations and increase shop operation and maintenance (O&M) costs to manage the pollution discharges. The company will have to assess these O&M costs but in general, the assessment team believes they will be small.

> The Samara Cable Company plant experts assigned as a part of the assessment team were Vladimir V. Satosov, deputy chief technologist, Vladimir Gorodecky, deputy technical director, and Galina Dorokhova, head of the Environmental Control Laboratory.
>
> The assessment team members assigned by Chemonics International and the Russian Engineering Academy's Volga Department were: Nicholas P. Cheremisinoff, team leader, K&M Engineering, Sergey V. Makarov, technical expert, Lubov Kirichenko, technical expert. In addition, Mr. Vladimir Skriagin, leading engineer from the Samara Bearing Plant, participated in part of the walk-though and was consulted on one of the pollution-prevention recommendations because of his extensive experience in metallurgy.

## B. Characteristics of the Operation

### B1. General Observations

Plant management restricted the assessment to the small cable shop. During the assessment, photography of the operations and equipment was permitted. The operation is housed in a portion of a one and a half-story building organized into a main shop area with a staged processing of operations.

The manufacturing operation is basically a copper wire-extrusion and spooling operation that precedes cable manufacturing, which is accomplished in another part of the plant. This portion of the plant operation involves processed rod passing along the entire technological line by means of a complex pulley-uptake and wire-drawing and extruding operation. Photographs 1a and 1b provide a view of the main shop floor and the end cable-spooling operation. A view of the large-spool cable-feed operation to the process is shown in Photo 2, and the train of wire extruders is shown in photographs 3a and 3b.

This shop operation uses an 8 mm diameter copper rod as the feedstock material. The final product, a pulled 1.8 mm diameter wire, is sent for subsequent processing into cable in adjacent shops. The shop also produces copper wire from 0.197 to 1.2 mm in diameter; tinned copper wire with diameters of 0.4, 0.5., and 0.8 mm; and braided (twisted) copper-conducting strand with cross-section from 0.5 to 6.0 sq. mm.

A material balance for the operation is provided in Table 1.

**Table 1. A Material Balance for the Process Operation**

| Materials | Totally Processed (t/y) | Material Consumption (t/yr) | | | Energy Consumption $10^3$ kWh |
|---|---|---|---|---|---|
| | | Used in product | Wastes | Not used in product composition | |
| Copper rod | 3,000.0 | 2,977.0 | 23.0 | | 1230 |
| Aluminum rod | 660.0 | 653.7 | 6.3 | | |
| Tin | 1.0 | | | 1.0 | |
| Soda ash | 0.3 | | | 0.3 | |
| Technical soap | 3.6 | | | 3.6 | |
| Kerosene | 1.2 | | | 1.2 | |
| Sunflower oil | 3.6 | | | 3.6 | |
| Vapor oil | 1.8 | | | 1.8 | |
| Graphite | 0.4 | | | 0.4 | |

### B2. Indoor Air-Quality Issues

The system has approximately 1,000 rollers, but only about 500 are estimated to be operational because of various reasons. The take-up and wire pulling/drawing pulleys are points of contact between the wire and steel rollers, and are exposed to the workroom environment. The manufacturing configuration requires that the wire, as it is being processed, change directions at numerous points in the manufacturing train. This results in the formation of copper dust from rubbing and attrition of fine copper-dust particles from the abraded wire surface. Points of contact and dust generators include:

- Rollers used in the unwinding rack
- The entrance draw-plate holder
- The tractive roller
- Rollers that comprise speed regulators on the extruders
- Rollers of the winding apparatus

There are also numerous contact points of copper dust formation in the technological circuit of the distributor-container.

Photo 4 shows typical rollers that are not encased and exposed to the workroom environment. Photos 5a and 5b show close-ups of the extruder-machine rollers and a significant amount of copper dust deposits on the machine walls.

In meetings with the local assessment-team consultant from the Academy, the results of an indoor air-quality study were provided, indicating significantly high occupational exposure levels to copper dust. However, upon further evaluation of this analysis, the following conclusions were drawn:

1. Proper statistical sampling and analysis methods were not followed.

2. The variances of data sets were larger than the average concentration taken at a spatial sampling point.

3. The above suggests that the airborne concentration measurements taken and conclusions drawn were suspect and hence the study should not be considered conclusive.

Despite this, copper dust deposits around machines and on the floor are evidence that there is an indoor air-quality issue at the operation. The previously conducted air-monitoring study obtained data by electron microscopy, confirming that air samples contained finely dispersed particulate matter with a narrow particle-size distribution. The uniqueness of the particle-size distribution supports the conclusion that the dust source is not random and can only be associated with the wire-processing operation.

Although the concentration of airborne copper dust in the workroom has not been quantified because of the numerous exposed surfaces, the health risk for workers is considered high. Excessive, long-term exposure to copper dust is associated with several health-related problems including severe gastroenteric anuria, hermaturia, anemia, increase in white blood cells, icterus, coma, respiratory difficulties, and circulatory failure. The highest occupational exposure risk is from inhalation in this operation, but there is also a risk from ingestion. Workers were observed to be carrying food and eating in the workroom area during operations. The toxicity by ingestion for copper dust and oxides of copper ranges from 0.5 to 500 mg/kg (rat). Late toxicity from chronic exposure causes liver, kidney, and testicle damage in rats. These data are taken from the *Handbook of Industrial Toxicology and Hazardous Materials*, N. P. Cheremisinoff, Marcel Dekker Publishers, New York, 1999.

### B3. Storm Water Discharges

In addition to the health risk created by the impact on indoor air quality, there is an environmental impact outside the workroom. The workroom air is exhausted directly to the atmosphere without any pollution-control devices to capture particulate matter. This dust settles onto the roof of the shop and the surrounding pavement. Also, traffic in and out of the shop area carries additional copper dust that settles onto the shop floor outside the building.

The enterprise has a storm-water monitoring and management program, whereby storm water is collected, monitored, and discharged into the local river. The storm-water discharge has been found to contain high levels of copper that often far exceed permissible discharge limits. Because

the storm water is not treated by the facility, pollution fees are imposed for this discharge. The total yearly cost for the discharge is 101,000 Ru, with about 50 percent of these pollution fees associated with exceeding copper-discharge limits. Hence, both an air quality and wastewater problem exist at the operation, and both can be related to a single source.

### B4. The Source of Emissions

As described above, the source of the copper dust emissions is the surface wear from the wire surface as it is pulled across rollers open to the workroom. In addition, numerous points in the operation train were observed where equipment misalignment caused other points of wire-surface wearing to occur with resultant dust generation. Photos 6a and 6b show an example of machine misalignment causing an additional wear surface on the cable.

Many examples in this process lend themselves to local control. Local control can be achieved by simply encasing the roller in a housing designed to capture the dust. Photo 7 shows an example of where this is feasible. Such an enclosure could be constructed from Plexiglas and would likely capture 90 percent or more of the dust at that point. However, this is not a practical solution — first, because of the number of rollers, and second, because the variety of sizes and configurations of rollers makes cost-effective encasement difficult (see Photo 8).

### B5. Product Loss Issues

The predominant product losses in the process are due to sludge formation in the wire-cooling and cleaning cycle of the process (described below). In addition, the copper dust generation is a fugitive emission from a product-loss standpoint. There are no reliable estimates of these losses, but very approximate calculations based on storm-water discharge calculations would suggest that two to three tons per year of copper dust may be lost due to the wire-attrition problem. Additional losses are likely due to poor equipment maintenance practices where significant buildup of copper dust accumulates. An example of this is shown in Photo 9. Current shop-management practices are to broom-sweep the shop floor and simply discard the sweepings, which are minor but incremental losses. Collectively, these losses could be sizable and are worth quantifying.

### B6. Solid Wastes

Other parts of the manufacturing train in the shop area include an emulsion used for cleaning and cooling the processed wire as it is extruded. The emulsion serves as a greasing/cooling liquid in the process of wire drawing. The composition of the medium is water, soap, and vegetable oil emulsion (2 percent soap, 2 percent vegetative oil). The fat content of the emulsion is 3 to 5 percent, and its pH typically ranges from 7 to 9. The emulsion supply to machines is accomplished by a day tank, and about 80 kg of this solution is needed for every ton of copper processed. The solution is 100 percent recycled in the process and is changed every six months, with the spent liquor sent to an on-site treatment facility. There was no time in the assessment to study this waste stream, but economic incentives may exist for extending the life of the solution to reduce wastewater discharges and raw chemical costs.

During this operation, copper particles and salt deposits settle into the water emulsion that is recycled through the extrusion stages. After the spent emulsion has been treated at the wastewater-treatment facility, it is discharged to a municipal wastewater facility, and collected

sludge is stored on-site. Once per quarter, this sludge is taken to an industrial landfill site at a yearly cost of 8,000 Ru.

Photos 10a and 10b show one of the cleaning/cooling baths used in the process. The froth shown in photographs is the sludge that is ultimately collected and disposed. Photos 11a and 11b show that the sludge buildup at a machine is significant during normal operation, and that poor equipment maintenance is practiced. Photo 12 shows one week's worth of accumulated sludge. Approximately 60 metric tons of sludge are generated and disposed of each year.

The average composition of this waste is about 80 percent moisture, with the solids containing about 10 percent copper and 10 percent inerts (mainly salts from the emulsion bath). The sludge has both too high a moisture content and too low a copper content to be of value for reclamation or product recovery by a local smelting operation. As a point of practical reference, at 80 percent moisture, the sludge has a consistency of thick mud, and at 60 percent moisture, its consistency may be described as crumbly. Additionally, there is some indication that the sludge is slightly thixotropic in its semi-fluid state. This makes it a difficult material to dry and process as waste.

### B7. Other Issues

The other significant process operation in the shop is an annealing step, which is accomplished in dual dome electrical furnaces (refer to Photo 13). Spools of copper rod are stacked and loaded into a tight muffler or canister, in which air is evacuated and displaced with carbon dioxide. Photos 14 and 15 show the loading operation and a close-up view of the canisters.

An unsafe practice observed in this operation is that, at the end of the thermal treatment stage, the $CO_2$ from the canister is directly expelled into the workroom area. This practice should be stopped, because ventilation in the workroom is poor and already stressed by the copper dust.

## C. Pollution-Prevention Opportunities

### C1. Financial Incentives

The economic benefits or financial incentives for implementing the recommended pollution-prevention measures, along with an environmental management plan for this shop, are:

Material losses:

- 60 t/yr of solid waste (sludge) containing about 10 percent Cu = 6 t/yr Cu losses
- estimated Cu losses to storm water discharge = 2.5
- estimated losses to floor sweepings = 0.5
- estimated losses in delayed equipment operation = 0.5
- Total material losses = 9.5 t/yr

A Cable News Network spot price for Cu is $0.65 per pound (lb). The estimated revenues in Ru (conversion 22.23 Ru per $) are:

$$\text{Value to enterprise} = 9.5\ \text{t} \times 2{,}000\ \text{lb/t} \times 0.65 \times 22.23 = 274{,}540\ \text{Ru/yr}$$

*Cost for sludge disposal:*

Yearly disposal costs to an off-site landfill = 8,000 Ru

*Polluted storm water discharges:*

Yearly cost for storm water discharge to local river = 101,000 Ru.

Assuming 50 percent of the charges are due to Cu pollution, the potential savings from total elimination are 50,500 Ru/yr.

Total economic incentives (1+2 +3) = 333,040 Ru/yr

*Other incentives that should be identified:*

- Improved worker productivity due to reduced health risks
- Improved process productivity (fewer downtimes and line interruptions) due to better equipment maintenance.

Not all of these economic incentives can be captured, however they do define the need to develop an environmental action plan aimed at minimizing the losses.

### C2. Pollution-Prevention and Abatement Measures

EAPS consultants identified pollution-prevention opportunities for the enterprise and organized them into a matrix, Tables 2 and 3. Table 2 prioritizes pollution problems and potential pollution-prevention opportunities for air, water, and solid waste media. Column (1) defines the pollution media. Column (2) defines the environmental health and safety impacts of the pollutant. Column (3) lists potential pollution-abatement measures identified by the assessment team. Column (4) defines the environmental, health and safety, and financial benefits that are likely to be achieved by the pollution-abatement measure. Column (5) provides an overall technical effectiveness rating for the pollution-prevention measure (i.e., a qualitative assessment as to how effectively the recommendation will minimize the pollution problem). The technical effectiveness rating is based on a high (H), medium (M), and low (L) assessment. Cost estimates for the recommendations are based upon single vendor quotations from local sources or suppliers identified on the Internet, or vendor quotes. The opportunity to identify multiple suppliers of recommended equipment for cost optimization was not possible during the assignment. The refinery will need to explore the availability and cost options available to them in the region to reduce some of the investment costs.

It is important to note that the matrix presented in Tables 2 and 3 attempt to prioritize the pollution-prevention and abatement measures for the specific shop, and hence form the basis of an environmental management plan. Although all the steps detailed in the *In-Plant Environmental Assessment Sourcebook: A Guide to Pollution Prevention Planning* were not followed because of time and budgetary restrictions, the present assessment does provide a first step to addressing the shop's environmental issues. It is recommended that the matrix summary approach given in Tables 2 and 3 be followed in other in-plant assessments in other parts of the enterprise. Collectively, these assessments can be used to develop a facility-wide environmental management plan, with identification of low-cost/no-cost opportunities.

### D. Recommendations

A final working session was held with representatives from the Samara Cable Company to establish an implementation plan for the recommendations. The meeting focused on the P2 recommendations made in Tables 1 and 2. Management agreed to begin implementation of all low-cost/no-cost recommendations, but will require some assistance from the EAPS project. Specifically, the plant requires a recommendation, and possibly some procurement assistance for an air-monitoring instrument for particulate matter. A recommendation for the instrumentation along with procurement recommendations are to be addressed within three to four weeks of completion of the in-plant assessment. These recommendations will be made both to USAID and the cable company. During this interim period, the local Russian consultant will work with the cable company to optimize the test matrix and on-site preparation for testing low-cost recommendation A1 (roller-maintenance program). Specifically, the consultant will follow through in assisting the plant with the following activities:

1. Arranging for polishing rollers on the test machine selected for the assessment;

2. Obtaining background data on particulate matter emissions from floor sweepings around the test machine;

3. Assessing whether the plant has an accurate weighing scale that will be needed for air-sampling tests. The air-monitoring instrument will likely be a high efficiency particulate air (HEPA) type of filtration unit.

Other recommendations made in Tables 1 and 2 are scheduled to be implemented beginning in early May. They will be monitored for savings (financial benefits) and improvements to environmental conditions through early to mid-September. Recommendation A5 is a corrective action (elimination of the unsafe practice of discharging $CO_2$ from furnace operations into the workroom). This recommendation will be immediately implemented and does not require any monitoring or follow-up activities. The assessment team leader will assess the program's performance at regular intervals. At least three EAPS follow-on progress reports are anticipated.

## Table 3. Recommended Environmental Action Plan and Priority Pollution-Prevention Opportunities

| Pollution-Prevention Recommendation | Enviromental Benefit | Estimated Cost | Estimated Savings or Economic Benefits | TER |
|---|---|---|---|---|
| **AIR POLLUTION** | | | | |
| *ity pollution problem.* Cu dust airborne contaminant caused by wire drawing and extrusion operation. | | | | |
| **LOW-COST/NO-COST POLLUTION-PREVENTION OPPORTUNITIES** | | | | |
| *Roller maintenance program.* Places of open contact of er wire with the router of the unwinding stack, entrance r, pulling roller of the winding device, etc. are the main ce of copper dust formation in the workshop. Dust ation takes place as a result of wire wearing against rough l surface of rollers. The recommendation is to increase the ess of polishing of the contact surface by ultra-fine nanical polishing. A two-phase approach is recommended:<br><br>*e I – Proof of Principle Demonstration:* Determine the tiveness of the recommendation at the first stage sion machines located in the center of the workshop, h is the most polluted area. The test should be performed wo parallel working machines: one with polished rollers and ther with the existing rollers. Before the test a thorough ing of the working areas including surfaces of machines be done. Test duration must be not less than 2 weeks. g this time, take regular measurements of copper dust ents in the working zone air. Sampling at the test hines must be done simultaneously at similar points of dust ation during equipment operation at the end of each shift. of sampling must not be further than 25 cm from the ce of copper-dust formation. On a daily basis collect by um with HEPA filter the sediment dust from the floor and hinery within a 1 m radius from the source. The collected should be accurately weighed to quantify the losses ssions). The measurements should be recorded on a ble spreadsheet (e.g., Excel) and statistically analyzed. | The environmental benefits are reduced air emissions and contaminated storm-water. Full-scale implementation of this measure could substantially reduce copper-dust formation in the working zone air and improve the air quality. At the same time, quantity of copper sediment on the roof of the workshop and surrounding territory can be reduced, thereby minimizing contaminated storm-water runoff to the Samara river. | Phase I (Proof of Principle Demonstration) is minimal. Recommendation must be evaluated, including impact on O&M costs for entire shop. Maximum number of rollers that may require surface treatment is 500. Number of rollers to be polished and frequency of polishing required to manage the air-pollution problem will determine actual O&M costs needed on a yearly basis. | Total potential financial benefits are:<br>(1) Reductions in contaminated storm-water pollution charges = 15,500 Ru/yr,<br>(2) Cu material losses to storm-water = 10,150 Ru/yr,<br>(3) material losses to floor = 14,500 Ru/yr.<br>(4) Increased worker productivity due to improved air quality. | H<br>H<br>M<br>H<br>H |

| Pollution-Prevention Recommendation | Enviromental Benefit | Estimated Cost | Estimated Savings or Economic Benefits |
|---|---|---|---|
| *A1. Roller-maintenance program,* (cont.). The statistical analysis of data sets should be aimed at the following: Confirmation that data sets for each machine (the control machine (i.e., the one with polished rollers), and the base case machine (the one without polished rollers) are statistically significant and representative of the operation. Determine whether a statistically significant difference exists between the control and base case machine, which will confirm the Proof of Principle.<br><br>The test should be repeated in two months for final confirmation.<br><br>*Phase II* – Implement the recommendation to about 30% of the shop machines, develop cost information, and continue monitoring test and control machine to assess frequency of polishing needed. Once that is ascertained and O&M costs are manageable, implement the recommendation for all machines. | See previous page. | See previous page. | See previous page. |
| *A2. Floor- and machinery-maintenance program.* There are significant amounts of copper dust sediments on the floor, engineering networks, and equipment. In many cases this dust is the source of secondary air pollution in the working zone. It is recommended to vacuum-clean floor and machinery in the workshop regularly. The collected dust may be used to manage the solid waste problem (Refer to Recommendation S1). | Same benefits as described above. This measure will supplement Recom. A1 by decreasing copper dust deposits and prevent their reintroduction into the air. | Two industrial vacuum cleaners with nozzle attachments and filters. About 11,000 Ru. | Material losses to floor = 14,500 Ru/yr. Increased worker productivity due to improved air quality. |
| *A3. Enclosure of major source emitters.* Many rollers offer the opportunity for enclosure. By enclosing the highest dust-generating rollers in a Plexiglas box or clear plastic bag (transparent so that the box can be emptied when sufficient accumulation has been collected), dust generation at the source can be captured. Additionally, by collecting and weighing the dust, an accurate estimate of the Cu losses due to dust generation can be obtained, providing further guidance and definition of incentives for the environmental management program. An air-monitoring program (Recom. A4) can assist in identifying the highest sources of dust generation. | This recommendation offers control at the source and would incrementally improve air quality and material losses. | Minimal. Plant could construct the enclosure. | Same incentives as defined above. |

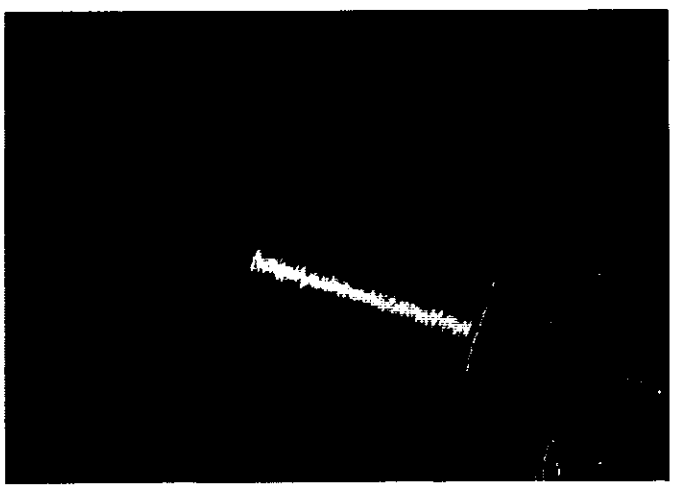
| Pollution-Prevention Recommendation | Enviromental Benefit | Estimated Cost | Estimated Savings or Economic Benefits |
|---|---|---|---|
| *A4. Air-monitoring program combination with A1 and A2.* Application of an air-monitoring program is needed to assess the full technical effectiveness of Recommendation A1, but also to provide guidance in an interactive management program for continual air-quality improvement to the workroom. It is recommended that the enterprise invest in proper air-sampling equipment using simple filters and an accurate scale to monitor only Cu dust. | Provides continual guidance for active program on air-quality improvement. | Under 20,000 Ru for an accurate scale and aspirator type air monitor with filters for particulate capture. | Same benefits as described above. |
| *A5. $CO_2$ decompression discharge to the outside.* The current practice for the wire-annealing operation in electric ovens takes place in a $CO_2$ media. At the end of the heating cycle, the carbon dioxide is evacuated from heating mufflers and discharged directly into the workroom. This practice should be stopped because it is a high health risk to workers. The $CO_2$ should be discharged to the outside atmosphere. This can be done with a simple hose connection to the canister-evacuation nozzle and the hose discharge sent through an adjacent outer wall. | The daily amount of $CO_2$ discharged to the workshop air is 100 kg. This is a dangerous practice that poses an extremely high health risk. | Cost is negligible. A 25 mm hose or pipe can be run from the discharge nozzle of the muffler to an outside wall. | Elimination of a dangerous work practice. |
| **LONGER RANGE POLLUTION PREVENTION OPPORTUNITIES** | | | |

| Pollution-Prevention Recommendation | Enviromental Benefit | Estimated Cost | Estimated Savings or Economic Benefits |
|---|---|---|---|
| *A6. Redesign of ventilation system with exhaust HEPA filters.* Plant should consider installing a ventilation system with exhaust ductwork equipped with high efficiency particulate air (HEPA) filters to remove 99% of the dust particulate matter from the workroom. The intake (supply) to the workroom could be operated intermittently because in the summer the workshop has natural ventilation through existing air ducts in the roof and open windows. | This is the proper solution to air-quality improvement in the workroom, but also would practically eliminate the contaminated storm-water discharge problem. | Proper design could be more than 500,000 Ru. Estimated ROI is under 10 years based solely on savings from reducing contaminated storm-water discharge. | Savings in pollution fees for contaminated storm-water discharges = 15,500 Ru/yr. |
| **WATER POLLUTION** | | | |
| *Priority Pollution Problem* – Cu-contaminated storm-water caused by air emissions. | | | |
| *W1. Improved storm-water monitoring and management program.* Plant should consider channeling storm-water runoff from outer perimeter of building to an outdoor sump with weir. Close monitoring of the flow can measure Cu contamination and average seasonal flow rates. If high levels of contamination can be related to seasonal and or certain operational periods, plant should consider on-site treatment options. | Better management of storm-water discharge problem by obtaining more accurate information on discharges at the source. | Minimal. Sump and weir may be constructed by the plant. Monitoring instrumentation may already exist. | Economizing pollution fees for contaminated storm-water discharges = 15,500 Ru/yr. |
| **SOLID WASTE** | | | |
| *Priority Pollution Problem* – High-moisture, semi-solid sludge with low Cu content generated as waste from wire treating. | | | |
| **LOW-COST/NO-COST POLLUTION PREVENTION MEASURES** | | | |
| *S1. Combine with wastes from A2, A3 to reduce water content and enrich Cu value.* Dry solid wastes recovered from Recommendations A2 and A3 can be combined with the sludge. These wastes are rich in Cu and will increase the overall Cu content of the sludge as well as reducing the moisture content. In addition, an aggressive, regularly scheduled maintenance program should be implemented aimed at cleaning internal machine surfaces and other parts of machinery with significant crud buildup. See photos 9, 11a, and 11b for illustrations of the problem. These wastes are also rich in Cu and may be combined with the sludge to increase its metal content. Increasing the Cu content of the sludge will make it acceptable to a local smelting operation. | Reduces on-site waste containment and eliminates the need for off-site disposal. Also may improve machine performance and/or lower maintenance costs. | Minimal. | Sludge disposal costs = 8,000 Ru/yr. |

| Pollution-Prevention Recommendation | Enviromental Benefit | Estimated Cost | Estimated Savings or Economic Benefits |
|---|---|---|---|
| *S2. Sludge-drying experiment.* Use one of the annealing ovens to dry the sludge to 40 to 50% moisture. An experiment and likely some modification may be needed for one of the ovens to evacuate the moisture during drying. A test would be needed to assess the drying time and energy-consumption requirements to determine whether this is a cost effective solution. If the sludge can be dried to the 40 to 50% moisture level, then it would likely be acceptable to the local Cu smelter. Energy requirements are not likely to be high, depending on the temperature limits of the oven and drying times needed. In addition, since there is not a large quantity of waste, this procedure may only be needed once or twice per quarter. | Reduces on-site waste containment and eliminates the need for off-site disposal. | Minimal if no major modifications to the oven are needed. | Sludge disposal costs = 8,000 Ru/yr. |

TER = Technical Effectiveness Rating

**Photos 1a and 1b.** View of shop floor cable-spooling operation.



**Photos 2a and 2b.** View of large spool cable feed operation to extruders.

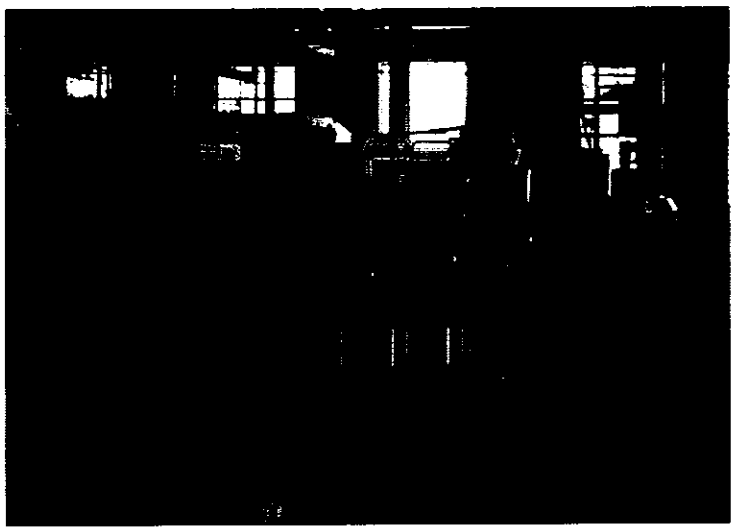


**Photo 3.** Cable extruders.

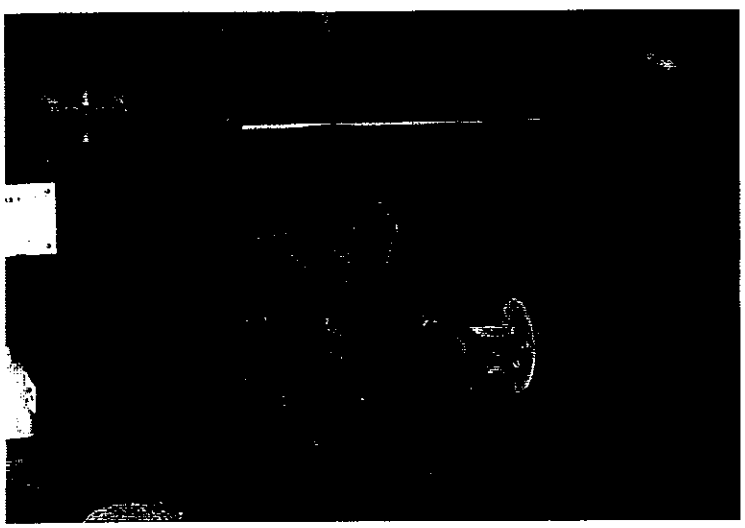
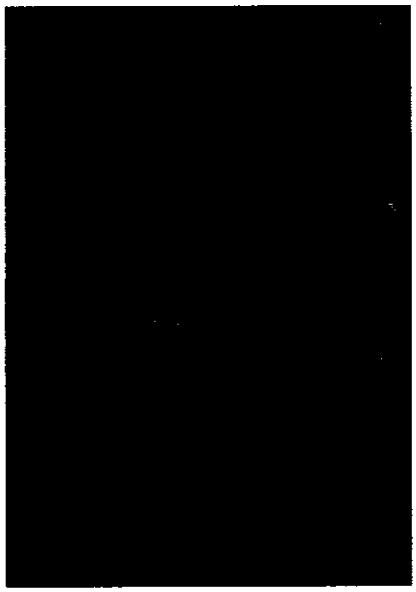
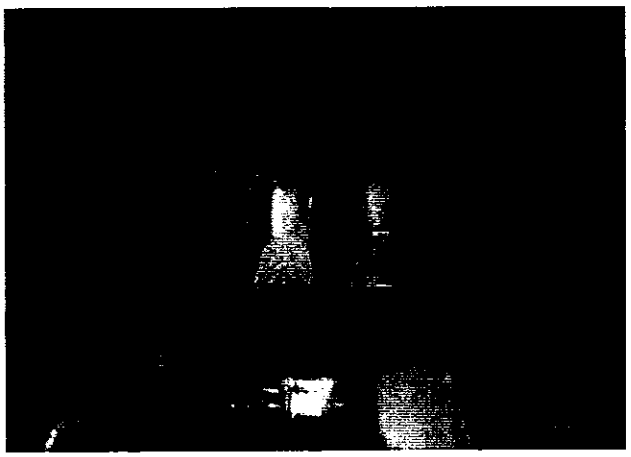
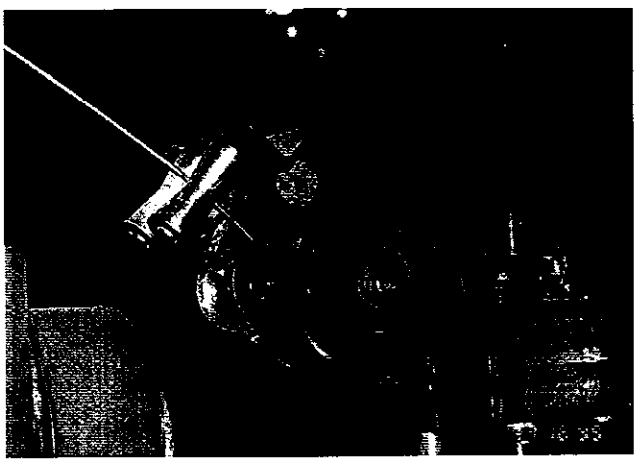


**Photo 4.** Typical exposed small rollers.



**Photos 5a and 5b.** Close-up of extruder-machine rollers showing copper dust deposits on machine walls.





**Photos 6a and 6b.** Examples of machine misalignment resulting in cable abrasion and dust attrition.

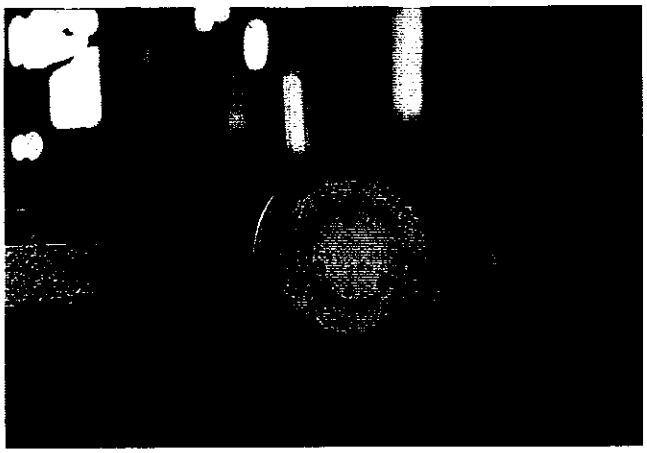


**Photo 7**. Example of a roller that could be encased to reduce attrition.

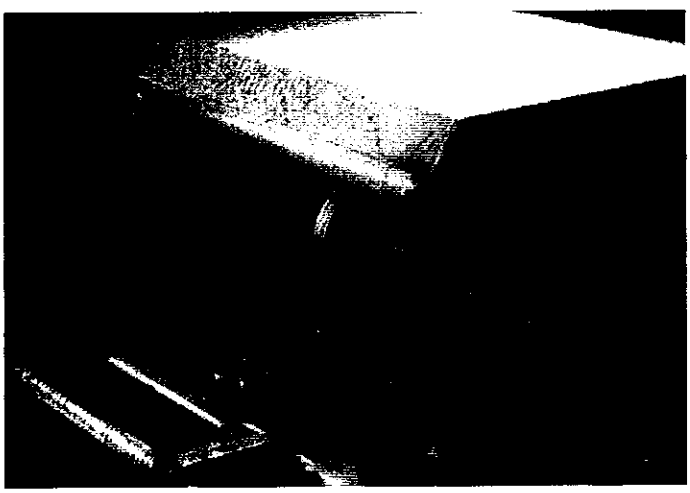


**Photo 8.** Varying sizes of extruder rollers in the operation.

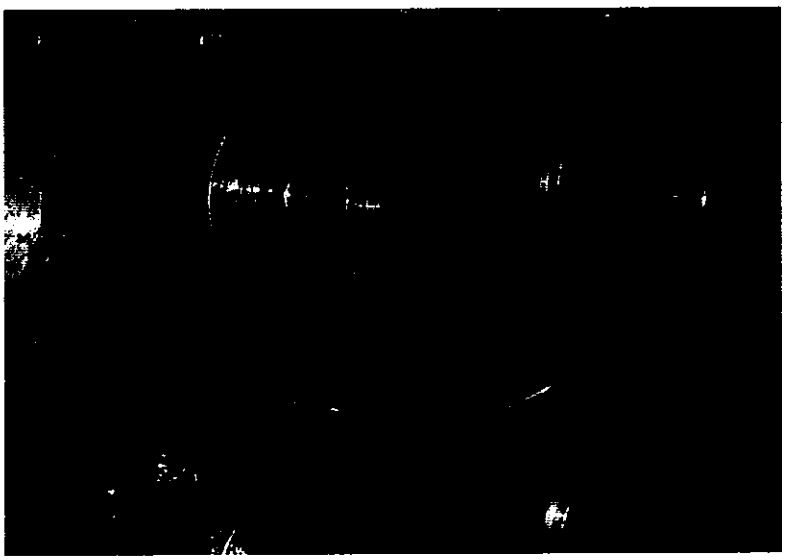
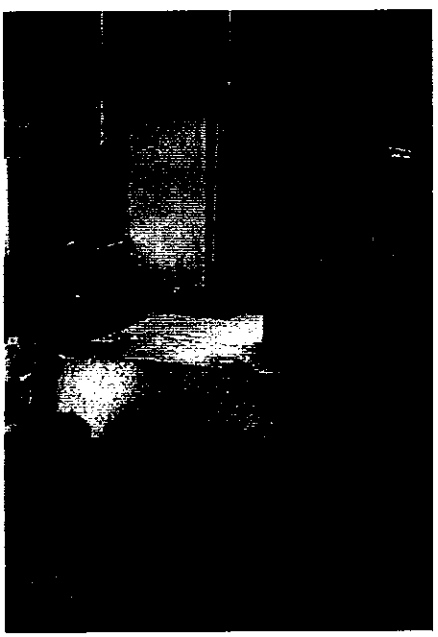
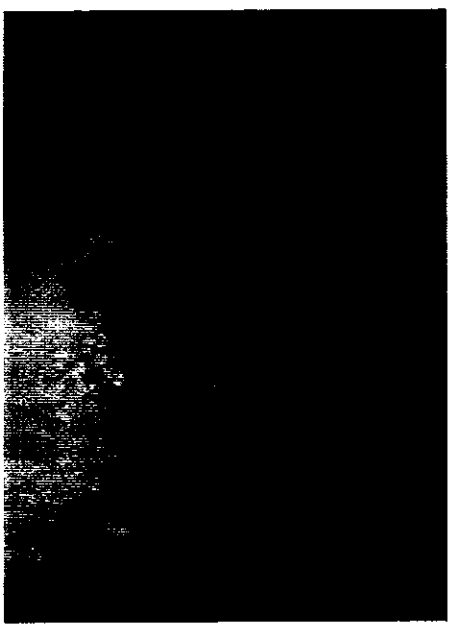
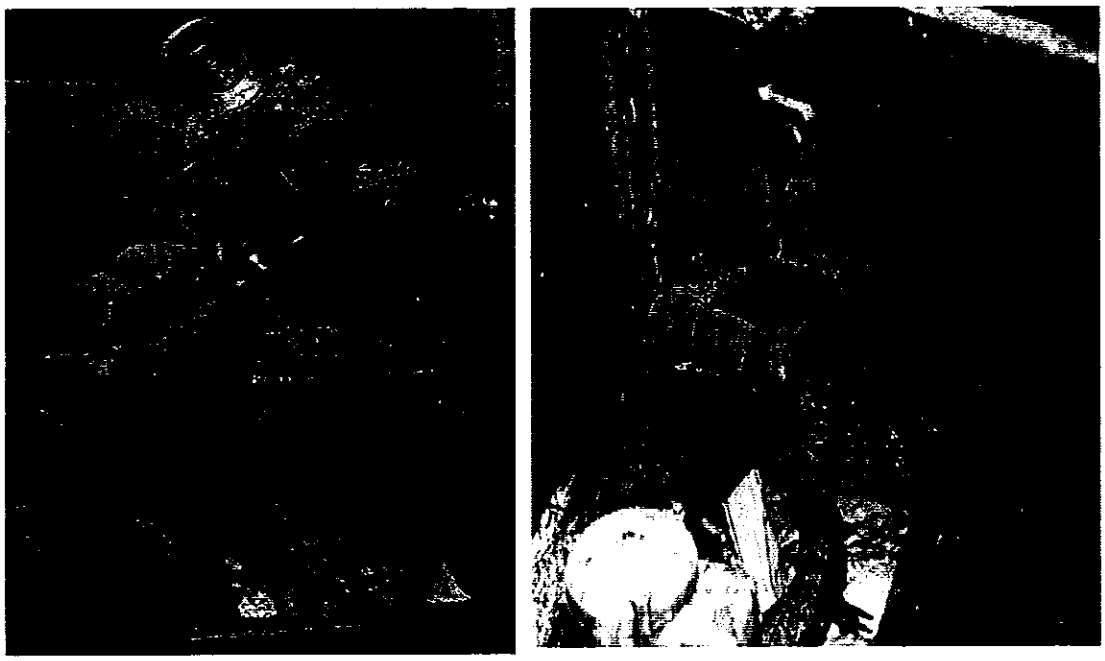


**Photo 9.** Inside rollers of a typical extruder. Significant buildup of deposits shows product losses and poor machine maintenance.





**Photos 10a and 10b.** Wire cable cleaning/cooling recycle bath at a typical machine with froth formation, the source of sludge.



**Photos 11a and 11b.** Sludge buildup at a machine indicating significant waste buildup and poor maintenance practices.

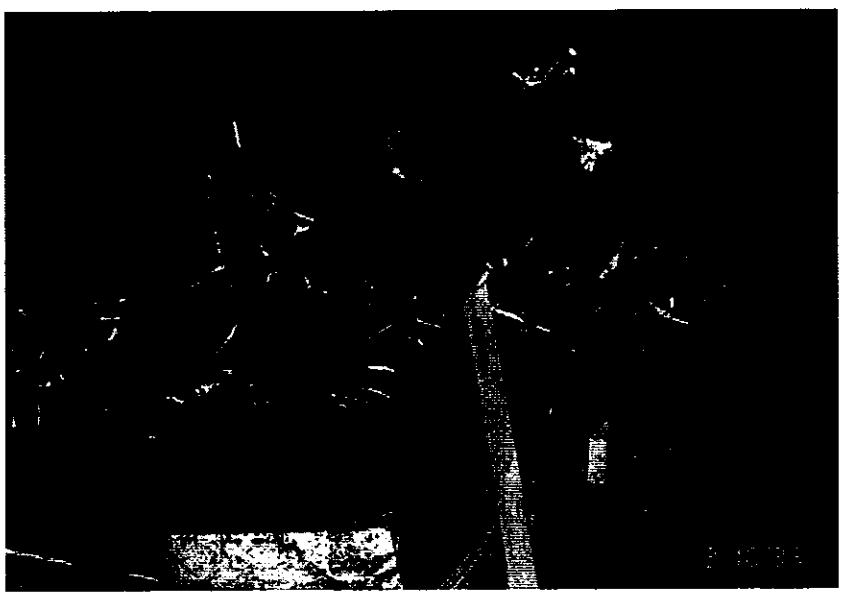


**Photo 12.** One week's worth of accumulated sludge.

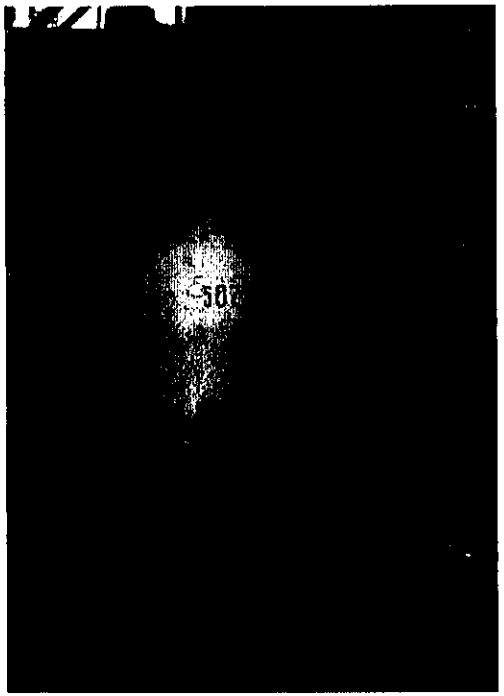


**Photo 13.** One of two furnaces for cable annealing stage of the operation.

**Photo 14.** Loading of cable spools into canister that is charged with CO2 for the annealing stage.

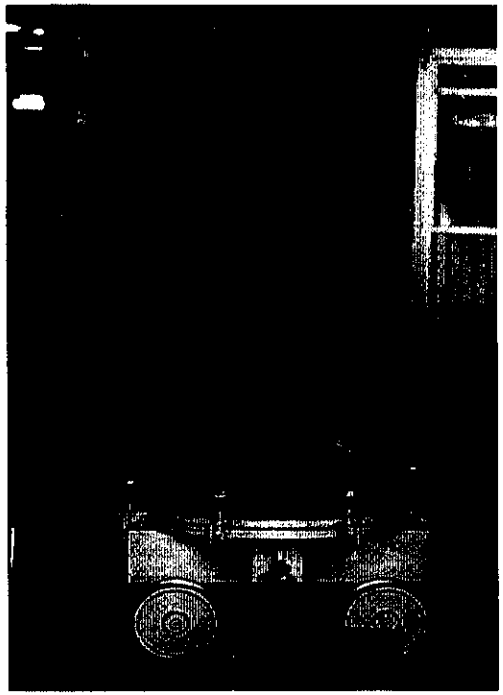


**Photo 15.** Shows close-up of canister.

## ANNEX A

# Pre-Assessment Pollution-Prevention Questionnaire

ANNEX A

# Pre-Assessment Pollution-Prevention Questionnaire

## Pre-Assessment Pollution-Prevention Questionnaire for the Samara Cable Company

| ITEM | INFORMATION REQUIRED | DATA |
|---|---|---|
| | **I. Process Operating Characteristics and Productivity Levels** | |
| I.1 | What are the types of cable manufactured in the shop area of interest (e.g. high voltage, medium voltage, low voltage, multi-purpose, fiber optics, other)? | |
| I.2 | What plastics are used for insulation and outer sheath coverings of cable products (e.g. – HDPE (high density polyethylene), LDPE (low density), EPDM (ethylene-propylene diene monomer) rubbers, other). If non-polymer based sheaths are used, list materials. | |
| I.3 | Are wire stretching and co-extrusion operations fully automated, semi-automated or manual? | |
| I.4 | How many operators are required per shift and what is the length of time of a shift production run? | |
| I.5 | How many hours throughout the year represent production? | |
| I.6 | How many hours throughout the year is downtime for maintenance reasons? | |
| I.7 | List all major steps (unit processes) in the production cycle of cable? | |
| I.8 | List any unit processes that are computer controlled. | |
| I.9 | If rubber or plastic compounding operations are performed in the production cycle, list the compounding ingredients. | |
| I.10 | What is the designed production capacity of the operation (i.e., how many meters of cable or tons of finished cable is the process designed for)? | |
| I.11 | What are total production capacities for the last 3 years? Give outlook production (projections) for 1999. | |
| I.12 | List reasons for shift (production) interruption and downtimes. | |
| I.13 | Is there a "critical path" stage in the production cycle (i.e., is there one or more processing steps which if interrupted cause the entire production to be interrupted)? | |
| I.14 | Does loss of product occur, typically how much per week or as a percentage of yearly production capacity, and what are the reasons for these losses? | |

| ITEM | INFORMATION REQUIRED | DATA |
|---|---|---|
| I.15 | What are the raw material costs (provide an itemized list with average unit prices)? | |
| I.16 | What are typical maintenance and equipment parts replacement costs throughout a year? | |
| I.17 | Do electrical power shortages occur at frequencies which cause significant process interruptions? | |
| | **II. Process and Product Quality Control and Assurance Characteristics** | |
| II.1 | Are any of your raw material suppliers ISO 9000 certified? If so, list the materials you purchase. | |
| II.2 | Describe the quality assurance steps or program you apply to those raw material suppliers that are not ISO 9000 certified. | |
| II.3 | What are the MAJOR raw material specs (i.e., quality control parameters) that are required of your raw material suppliers? | |
| II.4 | What are the MAJOR quality control parameters that the cable product must meet? | |
| II.5 | Are there any frequently occurring product contamination problems (particularly in coating or polymer processing operations)? | |
| II.6 | What "on-line" product quality control tests are conducted and what are the frequency of these tests? | |
| II.7 | How much off-spec product is produced in a year and why? | |
| II.8 | Is any control charting done for product quality control parameters? If so, provide typical charts. | |
| II.9 | Is any control charting done for process control parameters? If so, provide typical charts. | |
| II.10 | What are the production parameters that are controlled? | |
| II.11 | Has there ever been any attempt to model control parameters? | |
| II.12 | How much operator attention is required to control the process (e.g., continuous, intermittent – provide typical percentage or fraction of shift time devoted to control)? | |
| | **III. Energy Efficiency Characteristics** | |
| III.1 | Are there pumps used in the operation? How many pumps are used and for what purposes? What type of pumps are used (e.g., centrifugal, positive displacement, metering, other)? | |
| III.2 | If pumps are used, how are flow rates metered and controlled? | |

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| ITEM | INFORMATION REQUIRED | DATA |
|---|---|---|
| III.3 | If pumps are used, what types of drives are used (variable speed or constant)? | |
| III.4 | If pumps are used, what are the capacities of these units? | |
| III.5 | If extruders are used, how are line speeds controlled – in particular are they controlled to temperature set points, screw speed, take up rate, or combinations? | |
| III.6 | List all sources of energy consumption required to run the process. For examples:<br>• electricity consumption for wiring machines<br>• electrical consumption for pumps<br>• electrical consumption for lighting<br>• electrical consumption for ventilation<br>• heat for work room environment<br>• other | |
| III.7 | What is the unit cost for electricity and heating? | |
| III.8 | What energy measuring devices (if any) are used, how often and has an energy audit ever been performed? | |
| III.9 | Are the walls of the shop area insulated? Give characteristics of construction (e.g., brick walls, stucco walls, other, and the approximate thickness of the room). | |
| III.10 | What type of ventilation is provided in the shop area (natural, forced draft, other)? | |
| III.11 | What are the approximate dimensions or total volume of the shop area? | |
| III.12 | How many times in an hour is the volume of air displaced in the shop area? | |
| III.13 | Is the air temperature of the shop area measured and is it regulated? | |
| III.14 | Are there any hydraulic equipment used in the operation (if so, list them)? | |
| III.15 | What is the source of heating for the shop environment? | |
| | **IV. Environmental Management Characteristics** | |
| IV.1 | What environmental permits are there for the shop operation? | |
| IV.2 | List all waste categories and classes of wastes. Organize the list into 3 categories: Water Discharges, Solid Waste, Air Emissions. | |
| IV.3 | Are any wastes a result of raw materials stored in inventory and if so identify them? | |

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| ITEM | INFORMATION REQUIRED | DATA |
|---|---|---|
| IV.4 | Provide waste reporting forms or a summary of the amounts of each type of waste produced per year. Provide this data for 1998, 1997, and projections for 1999. | |
| IV.5 | Describe how wastewater is handled? Is it treated on site; is it sent to an off-site treatment facility; is it discharged directly to sewer or surface body of water? | |
| IV.6 | Describe how solid wastes are disposed of. Are they stockpiled and staged on site? Are wastes removed to a disposal or recycling facility? | |
| IV.7 | Are there any grinding, metal cutting or puncturing operations producing sweepings – identify them? What is done with the sweepings? | |
| IV.8 | Is there any form of recycling in the shop operation? Describe what is done and give an estimate of the amounts of materials recycled during a year. | |
| IV.9 | Are there any off spec products that can be sold into reclaiming markets or low cost markets? | |
| IV.10 | Are there any pollution control devices used in the shop operation? What are they and are they functioning? | |
| IV.11 | Is oil used for machine lubricating or heating purposes in the shop area? | |
| IV.12 | Are there oil losses in the shop operation? | |
| IV.13 | If oil is used, how is inventory maintained? Are there above ground or underground storage tanks, or is oil stored in barrels? What are typical inventories maintained throughout a year? | |
| IV.14 | Are there any fugitive emissions that you are aware of, if so describe them. | |
| IV.15 | How often is the facility inspected by the oblast ecological counsel? When was the last inspection, and were there any citations, fines, or corrective actions? | |
| IV.16 | Have there been any major fires or spills in the shop area within the last three years? If so, describe what happened. | |
| IV.17 | Do any of the wastes have a value and if so list them and their value? | |

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