URS

OPERATIONS AND MAINTENANCE MANUAL REV. 5 RED DOG TAILINGS MAIN DAM, NID ID# AK 00201 RED DOG MINE, ALASKA

For

TECK COMINCO ALASKA, INC.
URS JOB NO. 33755331
December 14, 2007

Original	–	September 19, 1989
Revision 1	–	August 27, 1999
Revision 2	–	February 18, 2000
Revision 3	–	April 7, 2004
Revision 4	-	August 5, 2005
Revision 5	-	December 14, 2007

URS

December 14, 2007

Mr. Jim Swendseid
Teck Cominco Alaska, Inc.
Red Dog Operations
3105 Lakeshore Drive, Building A, Suite 101
Anchorage, Alaska 99517

Operations and Maintenance Manual Rev. 5
Red Dog Tailings Main Dam (NID ID#AK 00201)
Red Dog Mine, Alaska
PO 1281090-SVC, Contract RD-2-06
URS Job No. 33755331

Dear Mr. Swendseid:

URS Corporation is pleased to submit to Teck Cominco Alaska, Inc. (TCAK) three copies of Operations and Maintenance (O&M) Manual, Revision 5, for the Red Dog Mine tailings main dam. TCAK authorized URS to update the manual as an addition to Purchase Order No. 1281090-SVC of Contract No. RD-02-06. The term "main dam" is now used so a so as to avoid confusion with the "back dam" that is being built.

This O&M manual Revision 5 supersedes all previous versions of the manual. Revision 5 of the O&M manual addresses the following three components of the Stage VII-B configuration of the dam:

- Tailings main dam (now includes the main embankment and a newly started wing wall)
- Seepage collection dam
- Seepage pumpback system.

The O&M Manual also includes a limited emergency action plan (EAP) that outlines procedures to be taken if any of the following is occurring:

- Failure is imminent
- Failure is in progress
- Failure is slowly developing or an unusual situation has occurred.

We trust that the O&M manual is adequate for permitting and operating the tailings dam. Please call if you have questions or need additional information.

Yours truly,

URS CORPORATION

Cecil M. Urlich, P.E.
Vice President

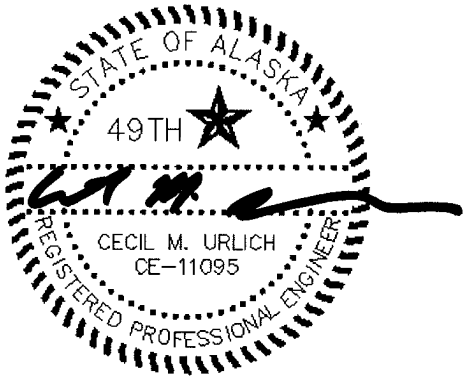
URS Corporation
1501 4th Avenue, Suite 1400
Seattle, WA 98101-1616
Tel: 206.438.2700
Fax: 206.438.2699

OPERATIONS AND MAINTENANCE MANUAL
REVISION 5

RED DOG TAILINGS MAIN DAM
NID ID# AK 00201

RED DOG MINE, ALASKA

Prepared by
URS Corporation
Century Square
1501 4th Avenue, Suite 1400
Seattle, Washington 98101-1616
Telephone: 206/438-2700



Prepared for
Teck Cominco Alaska Inc.
Red Dog Mine, 3105 Lakeshore Drive,
Building A, Suite 101, Anchorage, AK 99517

December 14, 2007

TABLE OF CONTENTS

FIGURES

APPENDICES

PROJECT DATA SHEET

A. GENERAL

Dam Name:	Red Dog Tailings Main Dam	
NID Number:	AK 00201	
Hazard Potential Class:	Class II	
Purpose:	Store tailings, tailings water, and surface runoff	
Year Built:	Stage I (Starter Dam), 1988	
Year Modified:	Stages II 1989; III 1990, IV 1991, V & VI 1993; VII-A, 2003; and VII-B 2005 to 2007 (includes wing wall).	
Location:	N 68-04-10.170 W 162-51-44.202	lat/long (GPS)
Reservoir Name:	Red Dog Tailings Impoundment System	
River or Creek Name:	South Fork Red Dog Creek	
Owner:	Teck Cominco Alaska, Inc.	
Owner Contact:	Jim Swendseid, P.E.	

B. DAM

Type:	Embankment dam raised by downstream construction	
Core Type:	Geomembrane liner on upstream slope & in cutoff trench	
Crest Length:	3457	
Crest Width:	52	feet
Crest Elevation:	960	feet
Crest Height (from d/s toe)	182	feet
Hydraulic Height:	173.8	feet

C. PRIMARY SPILLWAY

Type:	None-freeboard contains design storm, wave, & wind	
Location:	Not Applicable	
Spillway Crest Elevation:	Not Applicable	
Top Width:	Not Applicable	feet
Bottom Width:	Not Applicable	feet
Length:	Not Applicable	feet
Discharge Capacity at Dam Crest:	Not Applicable	cfs

D. EMERGENCY SPILLWAY

Type:	Not constructed, is planned for closure of tailings facility	
Location:	Not Applicable	
Spillway Crest Elevation:	Not Applicable	feet
Top Width:	Not Applicable	feet
Bottom Width:	Not Applicable	feet
Length:	Not Applicable	feet
Discharge Capacity at Dam Crest:	Not Applicable	cfs

E. OUTLET WORKS

Type:	Reclaim pump facility of 7 pumps on 2 barges	
Location:	Rock outcrop 1/3 way along east side of impoundment	
Inlet Invert Elevation:	937 (floating intake)	feet
Outlet Invert Elevation:	1032	feet
Diameter:	28	inches
Length:	5450	feet
Outlet Type:	Discharge to three water treatment plants	
Discharge Capacity at Dam Crest:	22.3	cfs

F. RESERVOIR

Normal Water Surface Elevation:	951.6 (December 6, 2007)	feet
Normal Storage Capacity:	19,573 (at Elevation 951.6)	acre-feet
Maximum Water Surface Elevation:	955	feet
Maximum Storage Capacity:	21,588 (at Elevation 955)	acre-feet
Maximum Surface Area at Dam Crest:	607	acres
Surface Area at Spillway Crest:	Not Applicable	acres

G. HYDROLOGY

Drainage Basin Area:	2.6	sq. miles
Average Annual Rainfall:	17.5	inches
100 Year/24 Hour Rainfall:	2.5	inches
100 Year Flood:	347	acre-feet
Probable Maximum Precipitation:	5.9	inches
Probable Maximum Flood:	818	acre-feet
Flood of Record:	Not Available	cfs
Inflow Design Flood:	758	acre-feet

1.0 INTRODUCTION

This Operations and Maintenance (O&M) Manual, Revision 5, provides operation and maintenance guidelines for the tailings main dam at the Teck Cominco Alaska Inc. (TCAK) Red Dog Mine in Alaska. The term "main dam" is now used instead of just "dam" so as to avoid confusion with the "back dam" that is currently under construction.

The tailings main dam is classified by the Alaska Department of Natural Resources (ADNR) as having a Class II (significant) hazard potential, as defined in Title 11 of Alaska Administrative Code (AAC) 93.157. ADNR assigns a Class II (significant) hazard potential classification to a dam if is determined that the failure or improper operation of the dam will result in:

> *(A) a significant danger to public health;*
>
> *(B) the probable loss of or probable significant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads, or public utilities, other than property losses or damage limited to the owner of the barrier;*
>
> *(C) other probable significant losses or damage, other than property losses or damage limited to the owner of the barrier ;*
>
> *(D) probable loss of or significant damage to waters identified under 11 AAC 195.010(a) as important for the spawning, rearing, or migration of anadromous fish.*

The O&M program is defined by the U.S. Bureau of Reclamation as a *"systematic means of ensuring that a dam is operated and maintained adequately for ensuring the continued safe operation of the dam and the continued productive use of the reservoir."* The O&M Manual for the Red Dog tailings main dam complies with this definition and with the requirements of "Guidelines for Cooperation with the Alaska Dam Safety Program" dated June 30, 2005.

This O&M Manual describes procedures for operating the Red Dog tailings main dam under normal and extreme reservoir level and flow conditions. It provides technical guidance and procedures for monitoring, inspection and long-term maintenance programs, and includes the following information:

- General information, including a description of the dam, its purpose and features, and identification of the parties responsible for its operations and for the O&M plan
- Project data sheet completed with information compiled during a dam safety inspection of the annual dam in May 2007, and completion of Stage VII-B construction in August 2007.
- Operating guidelines such as valve opening and closing procedures and stage-storage-discharge curves
- Schedule for routine maintenance of all aspects of the system that require continuous attention, as well as maintenance instructions, if required
- Schedule for routine inspection and monitoring, including a site-specific visual inspection checklist and data forms.
- Description of unusual conditions that could occur and operating procedures to be performed under those conditions, including special inspections and incident reporting.

- Emergency action plan to be implemented in the event of conditions where failure is either imminent or in progress, or where a failure or an unusual situation is slowly developing.

This Revision 5 of the O&M Manual for the tailings main dam supersedes previous versions of the manual. The responsibility, location and distribution of the manual at the mine site are discussed in Section 3.0.

2.0 PROJECT DESCRIPTION

Red Dog Mine is in northwestern Alaska near the southwestern end of the DeLong Mountains of the western Brooks Range. The main components of the mine are an open pit for the extraction of metal bearing ore, a milling and concentration facility, and the tailings impoundment that is contained by the tailings main dam. There are three components of the tailings main dam:

- Tailings main dam (now includes the main embankment and a newly started wing wall)
- Seepage collection dam
- Seepage pumpback system.

Plan and profile views of the tailings main dam are shown on Figure 1. Profiles along the highest section and along the crest are shown on Figures 2 and 3, respectively. Instrumentation locations are shown along with surface and subsurface conditions on Figure 4. These figures are based on the current dam conditions and 2004 topography. Details of the dam are provided in the Project Data Sheet. A summary of the dam is provided in the following sections.

2.1 TAILINGS MAIN DAM

The tailings main dam is operated as a "zero" discharge facility. It is a 182-foot-high rock fill embankment on an approximately west-east alignment across the South Fork of Red Dog Creek. It was built and raised in seven stages (Stages I to VII), with Stage VII built in two sequences (Stages VII-A and VII-B). The dam was raised by downstream construction to the current Stage VII-B crest at an elevation of 960 feet (El. 960).

The maximum height of the dam is approximately 182 feet and the crest width is 52 feet. The downstream slope has two inclinations: 3 horizontal to 1 vertical (3:1) above El. 880; and 4:1 below El. 880. The upstream slope is inclined at 2.5:1. The minimum freeboard for water in the impoundment is 5 feet, so that the maximum allowed water level is El. 955.

The dam contains internal seepage and drainage controls. The primary seepage control is a liner system on the upstream part of the dam from competent rock to the dam crest. The key element of the liner is a high density polyethylene (HDPE) geomembrane that is cemented into a cutoff wall under the upstream toe of the dam. The drainage control system consists of a toe drain along the upstream toe of the dam under the liner and a rock underdrain along the former creek channel.

Stages I to VII-A consist of an embankment across the South Fork of Red Dog Creek. Stage VII-B consists of a raise to the embankment and an extension (wing wall) southeast of the right abutment. The wing wall is

needed to protect the mill facilities for the rising tailings impoundment. As a result, the crest length of the main dam increased gradually to 2550 feet (Stage VII-A) and then increased significantly to 3457 feet (Stage VII-B). The Stage VII-B part of the wing wall is a seepage cutoff system (curtain wall).

The Red Dog tailings main dam now consists of the following major elements:

- A rockfill embankment across the South Fork of Red Dog Creek
- A rock under-drain from the Stage II downstream toe to the seepage collection pond
- A liner system containing a high-density polyethylene (HDPE) geomembrane
- A HDPE geomembrane lined cutoff trench below the upstream toe of the dam
- A HDPE geomembrane lined cutoff wall filled with grout and extending below the cutoff trench
- A rockfill buttress and stability berm on the upstream face to protect the HDPE geomembrane
- A pipeline utilidor for tailings discharge, seepage return and mine water discharge
- A pipe bench on the upstream dam face that supports the tailings discharge pipeline
- A curtain wall extending southeast from the right abutment of the embankment
- Proprietary interlocking HDPE "GSE CurtainWall" panels along the curtain wall
- Control density fill embedment along the bottom of the curtain wall panels
- Piezometer and thermistor instrumentation in and around the dam and wing wall.

Stages I (starter dam) to VI were constructed from 1988 to 1993. Stage VII was constructed as two 5-foot high raises (Stages VII-A and VII-B). Stage VII-A was constructed from September 2003 to February 2004. Stage VII-B was built during three construction seasons from July 2005 to August 2007. The main dam has no outlet or spillway because it is sized to contain all runoff from the design storm

2.2 SEEPAGE COLLECTION DAM

The seepage collection dam is located downstream of the tailings main dam for the purpose of capturing seepage from the tailings impoundment that flows through and under the main dam. The seepage collection dam consists of the following major elements:

- A rockfill dam across the South Fork of Red Dog Creek
- A 100-mil HDPE geomembrane on the upstream face of the dam
- A HDPE geomembrane lined cutoff trench extending up the east abutment
- A HDPE geomembrane lined cutoff wall filled with concrete below the cutoff trench
- A rockfill buttress and stability berm on the upstream face to protect the HDPE liner
- A partly lined spillway on the east abutment between the dam and cutoff trench
- A rock drain filling the remaining seepage pond area
- Piezometer instrumentation in and around the dam.

The seepage collection dam was built during the Stage I construction of the tailings main dam.

2.3 SEEPAGE PUMPBACK SYSTEM

The seepage pumpback system was installed in the impoundment area of the seepage collection dam for the purpose of returning seepage back to the tailings impoundment. It consists of the following major elements:

- Three pre-cast concrete pumpback chambers in the rock drain of the seepage collection pond
- Three vertical turbine pumps, one in each of the pumpback chambers
- A seepage pumpback pipeline from the pumps to upstream of the tailings main dam
- A magnetic-type flow meter connected to the seepage pumpback pipeline
- A well and pump secondary seepage collection system below the seepage collection dam
- A secondary seepage pumpback pipeline from the well to the seepage collection pond.

The seepage pumpback system was built during the construction of Stage I of the tailings main dam and the construction of the seepage collection dam.

3.0 RESPONSIBILITY

3.1 RESPONSIBLE PARTY

The overall responsibility for operating, and maintaining the tailings main dam should be assigned to a member of the mine staff (Responsible Party). In addition, one or more members of the mine staff should be designated as a back-up Responsible Party for when the Responsible Party is on leave from the mine.

The Responsible Party must have a basic understanding of engineering principles, operation and maintenance practices, should be experienced in operating and maintaining dams or similar structures, and should be aware of current tailings disposal practices and future tailings disposal and ultimate closure plans.

Suitable administrative controls and reporting procedures should continue to be implemented by mine management to monitor and assist the Responsible Party. Any plans of the mine, mill, environmental and other departments that relate to the tailings facility, such as conceptual designs of future raises to closure, should be discussed with the Responsible Party so that impacts to the tailings main dam can be considered.

The location of the official O&M manual shall be in the office of the Responsible Party. The Responsible Party shall distribute copies of the O&M manual to other mine staff with tailings facility responsibilities.

3.2 REGULATORY REFERENCE DOCUMENTS

The Responsible Party should have available, and be familiar with, the following documents prepared by the ADNR Dam Safety and Construction Unit:

- "Guidelines for Cooperation with the Alaska Dam Safety Program", June 30, 2006, based on revisions to Alaska dam safety regulations articulated under Article 3 of 1 AAC 93.

- "Certificate of Approval to Operate a Dam" to Teck Cominco Alaska Inc., for Red Dog Tailings Dam (NID ID#AK00201), January 22, 2004 (to be re-issued for Stage VII-B upon submittal and approval of this O&M manual).

3.3 PROJECT REFERENCE DOCUMENTS

The Responsible Party should have available, and be familiar with, the following project documents, or with any superceding updates of these documents:

- Dames & Moore, "Report of Investigation of Tailings Dam Borrow Sources, Red Dog Mine Site", for Cominco Alaska, Inc., July 1, 1985.
- Dames & Moore, "Design Report: Proposed Tailings Dam Red Dog Mine Development", for Cominco Alaska, June, 1986.
- Dames & Moore "Technical Specifications – Proposed Tailing Dam Red Dog Mine Development for Cominco Alaska, Inc." Revised April 11, 1988.
- Dames & Moore, "Construction Drawings for Cominco Alaska Inc., Tailings Impoundment Dam, Red Dog Project, Alaska", Revision 4, September 13, 1989.
- Dames & Moore, "Red Dog Mine, Tailings Dam Stage III Construction Completion Report", for Cominco Alaska Inc., December 3, 1990.
- Dames & Moore, "Completion Report, Tailings Dam - Stage IV, Red Dog Mine Development", for Cominco Alaska Inc., October 11, 1991.
- Dames & Moore, "Tailings Dam - Stage V and VI Completion Report", for Cominco Alaska Inc., October 13, 1993.
- Dames & Moore, Piezometer Design and Operation, Red Dog Mine Tailings Dam" for Cominco Alaska Inc., April 17, 1995.
- EBA Engineering Inc., "Cut-Off Trench Details, Red Dog Tailings Dam", letter to Cominco Alaska, Inc. January 16, 1990.
- Geomatrix, "Final Calculations Red Dog Tailings Dam Freeboard Analysis", for Teck Cominco Alaska, Inc., Revised June 18, 2003.
- Teck Cominco Alaska, Inc., "Red Dog Mine Tailings Geotechnical Assessment, Waster Management Permitting Program Task D-01" October 2004.
- Teck Cominco Alaska, Inc., "2006 Annual Instrumentation Report, Red Dog Tailings Dam, Red Dog Mine", January 10, 2007 (and all previous annual instrumentation reports).
- URS Corporation, "Stage VII Raise Red Dog Tailings Dam Construction Quality Assurance Plan", August 5, 2003.
- URS Corporation, "Construction Completion Report, Stage VII-A Raise, Red Dog Tailings Dam", March 30, 2004 (Contains Record Drawings and Photographs).
- URS Corporation "Periodic Safety Inspection Report No. 3, Tailings Dam, Red Dog Mine Project," May 27, 2005 (and previous Periodic Safety Inspection Report Nos. 1 and 2).

- URS Corporation "Technical Specifications for Red Dog Tailings Main Dam, Stage VII-B Raise," issued for construction May 27, 2005.
- URS Corporation "Construction Quality Assurance Plan for Red Dog Tailings Main Dam, Stage VII-B Raise". Inc. Issued for construction May 27, 2005.
- URS Corporation "Construction Quality Assurance Plan for Red Dog Tailings Main Dam, Revision 2," July 21, 2006.
- URS Corporation "Geotechnical Investigation Report for Red Dog Tailings Main Dam, Future Raises to Closure, July 28, 2006.
- URS Corporation "Electrical Cabinet, Piezometer and Dam Toe Water Evaluation, Red Dog Tailings Dam, February 26, 2007.
- URS Corporation "Technical Specifications for Red Dog Tailings Main Dam, Stage VII-B Raise, Revision 2", March 30, 2007.
- URS Corporation "Construction Quality Assurance Plan for Red Dog Tailings Main Dam, Revision 3," April 1, 2007.
- URS Corporation "Dam History Report, Red Dog Tailings Main Dam, Future Raises to Closure, September 14, 2007.
- URS Corporation "2007 Dam Safety Inspection Report, Dams and Weir Structure, Red Dog Mine", September 19, 2007(and previous annual dam safety inspection reports).
- URS Corporation, "Construction Completion Report, Stage VII-B Raise, Red Dog Tailings Dam", October 26, 2007 (Contains Record Drawings and Photographs).
- Water Management Consultants, "Quality Assurance Project Plan for the Hydrologic Characterization of the Tailings Impoundment, Red Dog Project", January 1998.

4.0 ROUTINE OBSERVATION AND MAINTENANCE

This section describes the daily, weekly and quarterly inspections that are required for the Red Dog tailings main dam and any actions and maintenance activities that are found to be necessary as a result of the inspection observations. The daily and weekly/quarterly inspection sheets are in Appendix A.

The inspections should focus on unusual behavior which includes the sudden development of springs, seeps, wet areas, whirlpools, cracking, sliding, slumping, deformation, rapid changes in tailings pond level, melting of snow or ice, breaks in the tailings discharge pipeline, erosion of the dam face and pipe bench, and similar events that are obvious deviations from normal conditions.

Another type of unusual behavior is a rise in the tailings pond water level above the maximum freeboard elevation of 955 feet.

4.1 DAILY INSPECTION

The tailings main dam, seepage collection dam, seepage pumpback system, and the surrounding areas should be visually inspected daily for any unusual behavior. An "EMS Daily Dam & Pumping Inspection Sheet" is attached in Appendix A. This sheet is applicable for the tailings main dam and seepage collection dam, along with other mine dams and diversion facilities.

The duties of the mine staff responsible for the daily inspection are to fill out the "Daily Dam & Pumping Inspection Sheet" by completing the following:

- Document the temperature and general weather condition
- Visually scan dams and the surrounding areas for unexpected behavior
- Promptly report any unusual behavior to the Responsible Party

In the event of an unusual behavior, the Responsible Party is to:

- Investigate and assess if the behavior is an unusual occurrence or emergency (as defined later in this O&M Manual), and take appropriate action
- Keep a written log of the date, nature of the unexpected behavior, action taken, and other pertinent information

4.2 WEEKLY INSPECTION

The tailings main dam, seepage collection dam, seepage pumpback system, tailing discharge system, water reclaim system, and the surrounding areas should be visually inspected weekly for any unusual behavior. This inspection is more detailed than the daily inspection, and is documented in the "Visual Tailings Dam and Seepage Pond Inspection" sheet in Appendix A.

The duties of the mine staff responsible for the weekly inspection are to fill out the "Visual Tailings Dam and Seepage Dam Inspection" sheet by completing the following:

- Identify the temperature range and general observations of the weather condition, wind, wave action and snow cover
- Visually scan the tailings main dam and seepage collection dam and the surrounding areas for unusual behavior
- Inspect the embankment and wing wall crest, toe, east buttress, west buttress, upstream slope and downstream slope for signs of cracks, slumps and seepage
- Promptly report any unexpected behavior to the Responsible Party and describe in the "Other comments" section of the inspection sheet.

In the event of unexpected behavior, the Responsible Party is to:

- Investigate and assess if the behavior is an unusual occurrence or emergency (as defined later in this O&M Manual), and take appropriate action

- Keep a written log of the date, nature of the unexpected behavior, action taken, and other pertinent information

4.3 QUARTERLY INSPECTION AND MAINTENANCE

At quarterly intervals, the Responsible Party should walk over the tailings main dam, seepage collection dam, seepage pumpback system, and surrounding areas, and inspect all accessible parts of the system. This inspection is documented in the "Visual Tailings Dam and Seepage Pond Inspection" sheet in Appendix A that is used for the weekly inspections.

The quarterly inspection shall include checking at least the following:

- All exposed surfaces of the dams including the pipe bench, pipeline utilidor, buttress, and embankment and wing wall crests for evidence of deformation, vertical or horizontal displacement, cracks, sags, escarpments, settlement, subsidence, sinkholes, erosion, sliding, slumping and frost heaving
- Dam toe, downstream area and abutments for springs, seeps, boils, or unusually wet spots, recording the location, pattern, discharge and its variation with tailings pond water level, turbidity, temperature, and duration
- Instrument installation conditions for signs of physical damage, malfunctioning or needed maintenance, and recent readings for signs of trends that could be related to observed conditions
- All exposed surfaces of upstream buttress and tailings pipeline bench for evidence of slope cutting caused by waves, slumping and sliding, and erosion caused by the discharge of tailings, returned seepage and diverted mine water.
- Condition of the pipelines along the pipe bench and pipeline utilidor for signs of physical damage, cracking, joint separation, or needed maintenance

Any deformation or cracking should be compared to previous conditions and to the behavior of other fills at the mine to evaluate its significance to performance of the system. The horizontal and vertical movements across areas of significant cracking or deformation should be monitored using surveying measurements.

For quarterly inspections, the Responsible Party is to:

- Keep a complete written record of each inspection and findings with the checklist. The points of interest shall be located using crest stations and offsets, or references to mapped locations
- Attempt to find the cause and evaluate the significance of any deviations noted during the inspections
- Schedule the necessary repairs and maintenance items identified during the inspection and ensure that they are completed
- Obtain the help of a dam specialist if unable to confidently assess the significance of any observations made during inspections
- Keep a written log of repairs and maintenance, including date and time of inspection, inspector name, description of repair or item, summary of action taken, date of action, and names of persons involved.

5.0 INSTRUMENTATION MONITORING

5.1 TYPES OF INSTRUMENTATION

Instrumentation for monitoring the Red Dog tailings main dam is shown on Figure 4 and includes:

- Piezometers for collecting water level data
- Thermistors for collecting temperature data
- Pump controls for keeping water in the seepage collection pond below prescribed levels
- A flowmeter for monitoring the rate of seepage pumped back to the tailings pond

The instrumentation results should be considered along with the inspection results and other data to evaluate if problems exist and the need for repair, maintenance or further investigation.

5.1.1 Piezometers

There are 24 operational piezometers in the tailings main dam and seepage collection dam to characterize water levels and ground water flow in the dams. The piezometers include 22 vibrating wire type transducers in the tailings main dam, and two open well transducers in the seepage collection dam. Standard operating procedures for the piezometers and thermistors are attached in Appendices B and C, respectively.

The piezometers are monitored to measure hydrostatic pore pressures in the dams and their foundations. The measurements provide information for evaluating the rates of seepage through the foundations and lower parts of the dams, and providing early warnings of any potential slope stability problems that could impact the integrity of the dams.

There are additional piezometers that do not directly affect the integrity of the dams. Their purpose is to monitor water levels above and below the permafrost. These piezometers are used primarily to characterize the hydrology of the tailings impoundment, and to study the effects of the tailings on water quality down gradient of the tailings dam.

Seven original pneumatic piezometers (P-01 to 07) were installed during the Stage I and II construction. P-01 to P-05 were placed in the main dam to monitor pore water pressures in the foundation and embankment. P-06 was installed in the main dam to monitor the phreatic surface in the creek thaw bulb. P-07 was placed in the seepage collection dam to monitor pore water pressures in the foundation and embankment.

The pneumatic piezometers P-01 to 07 were replaced later by vibrating wire piezometers as described in Section 5.1.1.1, and were abandoned so that they are no longer operational.

5.1.1.1 Tailings Main Dam Piezometers

There are 21 operating vibrating wire piezometers in the tailings main dam. They are manufactured by Geokon of Lebanon, New Hampshire. Of these piezometers, 13 were installed in 1997 when the dam was at the Stage VI level of completion and eight were installed in 2005 as part of the geotechnical investigation for the conceptual design of the future raises to closure and for final design of Stage VII-B.

Six piezometers (P-08A, P-08B, P-09A, P09B, P-10A and P-10B) are paired at three locations (P-08, P-09 and P-10) along the alignment of the original creek under the highest part of the dam. These piezometers monitor the underdrain. At each location, the "A" piezometer records water pressure in the underdrain near the base of the embankment above the original ground surface. The "B" piezometer extends deeper into the foundation rock under the underdrain. The P-08A transducer is in the underdrain.

Five piezometers (P-11, P-12A, P-12B, P-13 and P-14A) are at four locations (P-11, P-12, P-13 and P-14) from west to east along the crest alignment of the dam. P-12A terminates in the embankment. The other four piezometers extend into the foundation rock under the dam. P-12B and P-14A have been frozen since their installation in August and September 1997.

Two piezometers (P-97-28 and P-97-31) are at two locations along the rockfill buttress on the downstream toe of the east abutment. The east-most piezometer (P-97-31) terminates in the embankment. The west-most piezometer (P-97-28) is on the downstream extension along the original creek of the line of P-08, P-09 and P-10. Two other piezometers (P-97-29 and P-97-30) were installed between P-97-28 and P-97-31, and extended into the foundation rock under the dam. P-97-29 has been frozen since January 2001. P-97-30 has recently stopped functioning. P-05-69 was installed in 2005 to replace P-97-29, but now serves as a replacement for P-97-29 and P-97-30.

Eight piezometers (P-05-61, P-05-62, P-05-63, P-05-65, P-05-67, P-05-68, P-05-69 and Riser Pipe) are in four general locations in and around the main dam. P-05-61 is at the west abutment. P-05-62 terminates in the underdrain near the toe of Stage VII-B to supplement the line of P-08, P-09, P-10 and P-97-28. Piezometers P-05-62, P-05-63, P-05-65, P-05-67 and P-05-69 are around the possible future wing wall alignment. P-05-69 is along the rockfill buttress of the downstream toe to replace the frozen P-97-29 and the malfunctioned P-97-30. The Riser Pipe piezometer was installed in the west riser pipe that is built into the embankment.

Each piezometer in the tailings main dam has an internal built-in thermistor so that frozen-ground conditions can be detected.

5.1.1.2 Seepage Collection Dam Piezometers

There are two operating piezometers in the seepage collection dam. They are located along the alignment of the original creek.

One piezometer (SPP-97-001) is operating immediately west of the western-most pumpback chamber between the downstream toe of the tailings main dam and the seepage collection pond.

One piezometer (SPP-97-002) is operating under the west part of the dam to monitor the water levels in the dam and its foundation, and provide data for evaluating the effectiveness of the dam as a seepage barrier.

These piezometers are open well screens built using standard monitoring well construction methods. An electronic water level indicator is used to measure water depth in the piezometers.

5.1.2 Thermistors

There are 15 thermistors in operation for monitoring the tailings main dam and seepage collection dam and the shallow active zone under the dams. Each thermistor well consists of a string of thermistors hung in a PVC pipe, with individual thermistors spaced 10 feet apart. The thermistors are YSI 44034 equivalent manufactured by Dryden Instrumentation of Anchorage.

Eleven thermistors (T-01 to 08, T-10, T-11 and T-13) were installed at the time of the Stage I and II embankment construction. T-01 to T-07 were placed next to the original similarly-numbered pneumatic type piezometers (P-01 to P-07) that were abandoned, as described in Section 5.1.1.

Six thermistors (T-05-61, T-05-64, T-05-65, T-05-66, T-05-67 and T-05-69) were installed as part of the geotechnical investigation for the conceptual design of the future raises to closure and for final design of Stage VII-B. They were placed in the same locations as the similarly numbered piezometers described above.

The operating thermistors measure the temperatures of the dam embankments and foundations to monitor the rate of thaw that is occurring in the foundation material, and indicate the presence and extent of thawed zones through which seepage could occur.

5.1.2.1 Tailings Main Dam Thermistors

There are 14 operational thermistor strings at the tailings main dam.

Three thermistors (T-01, T-02 and T-03) are located on the existing crest of the dam above the underdrain system, adjacent to the original but now abandoned piezometers P-01, P-02 and P-03, respectively. They were installed to monitor the thermal conditions of the embankment and foundation and the underlying creek thaw bulb.

Three thermistors (T-04, T-05, and T-08) are located along the crest alignment of the starter dam and are now buried with tailings. T-04 and T-05 were installed adjacent to the original but now abandoned piezometers P-04 and P-05, respectively. The thermistors were installed to monitor the thermal conditions of the embankment and foundation. T-05 and 08 were placed to monitor the underlying creek thaw bulb.

Two thermistors (T-14 and T-15) are located on the west and east abutments of the dam, respectively, to monitor the thermal conditions of the abutment foundation materials.

Six thermistors (T-05-61, T-5-62, T-05-64, T-05-65, T-05-66 and T-05-67) are located in three general locations around the main dam. P-05-61 is at the west abutment. T-05-62 was placed to monitor underlying creek thaw bulb near the toe of Stage VII-B and supplement T-05 and T-08. Thermistors T-05-64, T-05-65, T-05-66 and T-05-67 are around the possible future wing wall alignment.

5.1.2.2 Seepage Collection Dam Thermistors

There is one operational thermistor string (T-07) in the seepage collection dam. It is located on the crest of the seepage collection dam at the highest part of the dam. It was installed next to the original but now

abandoned piezometer P-07. It was placed to monitor the thermal conditions of the embankment and foundation and the underlying thaw bulb.

5.1.3 Pump Controls

There are three 7000 series vertical turbine pumps, one in each chamber of the seepage pumpback system. The pumps were supplied by Fairbanks Morse Pumps of Alaska. The pumps consist of five basic components: pump bowl assembly, column pipe, line shafting, discharge head, and driver. Installation, operation and maintenance instructions for the pumps are in Appendix E.

The operation of each pump is triggered by the water level in the seepage collection pond. The pumps are activated when the water level in the well exceeds the following elevations:

Start	Summer	Winter
Pump 1	El. 778	El. 790
Pump 2	El. 776	El. 788
Pump 3	El. 774	El. 787

The starting sequence of the pumps is varied as operations require. Each pump is automatically shut off when the water level in the well falls below the following elevations:

Shut off	During Summer	During Winter
All Pumps	El. 772	El. 785

5.1.4 Flow Meter

One magnetic-type flow meter is located in the seepage pumpback pipeline to monitor the rate of flow back to the tailings impoundment. The rate of pumpback water measured by the flow meter is estimated to be the combined rates of seepage from the tailings impoundment through and under the main dam, plus runoff from the watershed of the seepage collection pond.

The flow meter is a Rosemount Series 8700 Magnetic Flowmeter System that combines separate flow tube and transmitter units. The system measures the volumetric flow rate by detecting the velocity of fluid the passes through a magnetic field. It is manufactured by Rosemount Inc. of Chanhassen, Minnesota. The operator manual for the flow meter is included in Appendix F.

The flow tube unit is installed in-line with the seepage pumpback pipeline. Coils are located on opposite sides of the flow tube and create the magnetic field. The water being pumped through the seepage pumpback pipeline moves through the magnetic field and generates a voltage that is detected by two electrodes.

The transmitter unit drives the coils to generate the magnetic field and electronically conditions the voltage that is detected by the electrodes. The transmitter then produces output signals that are proportional to the velocity of the water as it flows from the seepage collection pond to the tailings impoundment.

5.2 DATA COLLECTION

5.2.1 Frequency of Data Collection

Water elevations in the tailings impoundment are to be recorded:

- Weekly, under normal operating conditions
- More frequently if:
    - flooding causes the tailings impoundment water surface level to exceed El. 955
    - unusual seepage develops at or near the dam
    - any piezometer shows sudden or unexplained changes in water level.

Piezometers are to be read:

- Quarterly under normal operating conditions
- Monthly if the tailings impoundment water level is changing at a rate faster than six inches per day
- Weekly if the tailings impoundment water level is changing at a rate faster than one foot per day
- Daily or more frequently if:
    - flooding causes the tailings impoundment water level to exceed El. 955
    - unusual seepage develops at or near the main dam
    - any piezometer shows sudden or unexplained changes in water level.

Thermistors are to be read:

- Monthly under all operating conditions

The seepage pumpback system flow meter is to be read:

- Daily under all operating conditions.

Some event may require that readings be taken more frequently than under normal operation conditions. Such readings must continue at the increased frequency until the event is over, and until either the readings have returned to the pre-event condition, or the situation has stabilized.

During the next PSI of the tailings dam, the schedule of readings should be reviewed and the reading intervals should be modified as warranted.

5.2.2 Data Collection Methods

The elevation of water in the tailings impoundment and the location of any unusual seeps should be noted when the instrumentation data are recorded.

The Responsible Party must be alert for erratic or unreasonable readings that may indicate instrument malfunctions or operator error. Instruments must be re-read or repaired as necessary. Piezometer data should be disregarded if the internal thermistors indicate frozen ground.

After each three years of operation, the schedule of readings should be reviewed and the reading intervals should be modified as warranted.

5.2.2.1 Piezometer Data Collection

Data from the vibrating wire piezometers in the tailings main dam are read using a GEOKON GK-403 data recorder. The piezometer readings should include resistance values from each piezometer. Standard operating procedures for collecting piezometer data are in Appendix B. Inspection, calibration, and maintenance procedures for the recorder are in Appendix D.

Data from the piezometer locations P-08, P-09, P-10, P-97-28 and P-05-62 provide a water surface profile in the dam and foundation materials along the original creek alignment, from upstream to downstream.

Data from the piezometer locations P-05-61, P-11, P-08, P-12, P-13, P-14 and P-05-63 provide a water surface profile in the dam, foundation and abutment materials from the west abutment to the east abutment.

An electronic water level indicator is used to measure water depths in the open well piezometers in the seepage collection dam.

5.2.2.2 Thermistor Data Collection

Thermistor data can be read either manually or with automated data recording devices. Thermistor readings should include resistance values from each thermistor. Data from thermistors are read using either:

- The automated procedure using an HP 200 data collector and a T5KMUX analog to digital converter and multiplexer
- Fluke multimeter and Dryden instrumentation switchbox

The standard operating procedures for collecting data using these devices are summarized in Appendix C.

The inspection, calibration, and maintenance procedures for the above devices are summarized in the Quality Assurance Project Plan (Water Management Consultants Report, "Quality Assurance Project Plan for the Hydrologic Characterization of the Tailings Impoundment, Red Dog Project", January 1998), and are included in Appendix D.

5.3 DATA REDUCTION AND INTERPRETATION

Basic interpretation methods are to be used by the Responsible Party. However, interpretation of instrumentation data is, in part, judgement. If unusual readings occur or if the Responsible Party is unable to confidently assess the meaning of the data, obtain the help of a specialist.

The reduction of data can be accomplished manually or by computer. Computer processing using conventional spreadsheet or data base software is the industry norm.

5.3.1 Piezometer Data

5.3.1.1 Piezometer Data Reduction

All piezometer readings are to be reduced to provide the following values:

- Pressure Head (Hp) -- measured resistance multiplied by calibrating factor (feet)
- Total Head (Ht) -- sum of Pressure Head and elevation of piezometer tip (feet)
- Normalized Total Head (N) -- ratio of Total Head in feet (Ht) to pond water surface elevation in feet (P), with pond bottom as datum:

$$N = \frac{H_t - 781.2}{P - 781.2}$$

where, 781.2 feet is the elevation of the pond bottom at the low point of the pumpback system.

5.3.1.2 Piezometer Data Interpretation

The following graphs are to be plotted for each piezometer reading:

- Total Head (Ht) and pond water surface elevation (P) against date
- Normalized Total Head (N) and pond water surface elevation (P) against date

Under normal operating conditions, it is sufficient to plot the above graphs for piezometers located along the alignment of the maximum section of the embankment (P-08A, P-08B, P-09A, P-09B, P-10A, P-10B, P-05-62 and P-05-62).

Under emergency situations, it is critical to plot the above graphs for piezometers that are pertinent to evaluate the nature of the emergency.

The above graphs must be inspected for patterns, which could point to the elevations at which seepage pathways may exist through the liner, cutoff, and foundation. It is important also to look for indications of gradual increases in foundation permeability due to thawing or other effects. The following list contains a few patterns that should be of concern:

- Disproportionate changes between Total Head in the piezometer and variation of the water level in the tailings impoundment
- Abrupt or inconsistent changes in Normalized Total Head, which should remain near-constant or change only gradually
- Gradual shifts in piezometer response on either graph as time passes
- Patterns that appear inconsistent or difficult to explain

The significance of piezometer readings for dam stability should be checked if the readings exceed the tabulated values below:

Piezometer	P-05-62	P-10	P-09	P-08
Water Level	El. 813	El. 814	El. 822	El. 833

5.3.2 Thermistor Data

5.3.2.1 Thermistor Data Reduction

Thermistor string readings should be reduced to convert resistance to temperature. The readings should be stored or filed as complete profiles for each date.

- Plot the thermistor data as temperature contours with depth against date
- Look for trends as to the enlargement or contraction of the thawed zone

5.3.2.2 Thermistor Data Interpretation

If thermistor readings at a single instrument location are to be compared for a limited number of readings:

- Plot the profiles as thermistor elevation against temperature
- Look for changes in active zone depth, thawed zone development, and ground temperature shifts.

5.3.3 Pump Control and Flow Meter Data

The total seepage pumpback flow rate measured by the flow meter consists of seepage from the tailings impoundment that passes through and under the main dam, plus runoff from the catchment area of the seepage collection pond that flows into the seepage collection pond:

- Plot the seepage discharge rate and tailings impoundment water level elevation against date
- Look for changes in the data pattern that may indicate where seepage pathways may exist

6.0 EMERGENCY ACTION PLANNING

Dam failures can have devastating impacts on people, property and the environment. Therefore, it is necessary to develop procedures for unusual occurrences and to have an emergency action plan (EAP) in place, and to be prepared in advance of unusual occurrences and emergency situations.

6.1 UNUSUAL OCCURRENCE PROCEDURES

6.1.1 Unusual Occurrences

Unusual occurrences are events or conditions that are not normally encountered during routine operations and which may endanger the facility. Examples include:

- Storms and Floods
- Earthquakes
- Increased seepage or changes in seepage character
- Landslides near the dam that do not cause dam failure

- Fire or explosions
- Human Interference by terrorism, vandalism, or accidents
- Incidents of potential environmental damage
- Imminent rise of tailings pond level above flood storage threshold.

6.1.2 Unusual Occurrence Procedures

The following steps are to be taken in the event of an unusual occurrence:

- Immediately report unusual occurrences to the Responsible Party
- Promptly make a special inspection and evaluate the significance of the occurrence
- Take protective or corrective actions as appropriate for the nature of the occurrence
- Activate emergency procedures discussed below, if necessary
- If emergency procedures are activated, inform State Dam Safety Engineer within 24 hours.

6.2 EMERGENCY ACTION PLANNING

6.2.1 Purpose of an Emergency Action Plan

The Guidelines for Cooperation with the Alaska Dam Safety Program, define the purpose of the EAP is to:

- Protect lives, property, and the environment if an emergency condition develops at a dam
- Prepare owners, operators, and emergency management personnel for the emergency event, in advance
- Detail actions and measures that will be taken by all parties responsible for responding to an emergency
- Facilitate the coordination and cooperation of the various emergency responders.

6.2.2 Emergency Situations

According to the Guidelines for Cooperation with the Alaska Dam Safety Program an emergency condition is assumed to occur if either of the following conditions are found to exist:

- An impending or actual release of water, mine tailings, or other substances caused by improper operation, accidental damage, sabotage, or general failure of a dam, penstock, or other appurtenances
- An impending flood conditions, even when the dam is not in danger of failure.

6.2.3 Definition of Emergencies

Three categories of emergency situation are identified and defined in this EAP:

- Failure is Imminent
- Failure is in Progress
- Failure is Slowly Developing or an Unusual Situation has Occurred.

Failure is imminent if the following situation is occurring:

- Tailings main dam freeboard is less than 2 feet

Failure is in progress if any of the following situations are occurring:

- Tailings main dam is cresting
- Tailings main dam is failing
- Seepage collection dam is cresting
- Seepage collection dam is failing

Failure is slowly developing or an unusual situation has occurred if any of the following situations occur:

- Tailings main dam or seepage collection dam behaves unexpectedly
- Earthquake felt at the site
- Human interference (vandalism, terrorism or accident)

These possible emergency situations are presented in detail in Section 6.2.8.

6.2.4 Responsibilities

Day-to-day operation and maintenance:

- Responsible Party

Identify conditions or events that require emergency action:

- Responsible Party

Implementation of Emergency Action Plan:

- Incident Command Center (ICC)

The Responsible Party is also responsible for the following:

- Provide on-site technical operation and maintenance expertise
- Contact the State Dam Safety and Construction Unit in Anchorage
- Contact the dam design engineers: URS Corporation in Seattle.

The ICC is responsible for the following:

- Notify the Phil Driver big game hunting and fishing camp
- Notify residents in the villages of Kivalina and Noatak
- Mobilize on-site resources and equipment
- Obtain emergency supplies and equipment
- Take emergency measures at the dam to prevent failure
- Control information and inform press and news media if necessary.

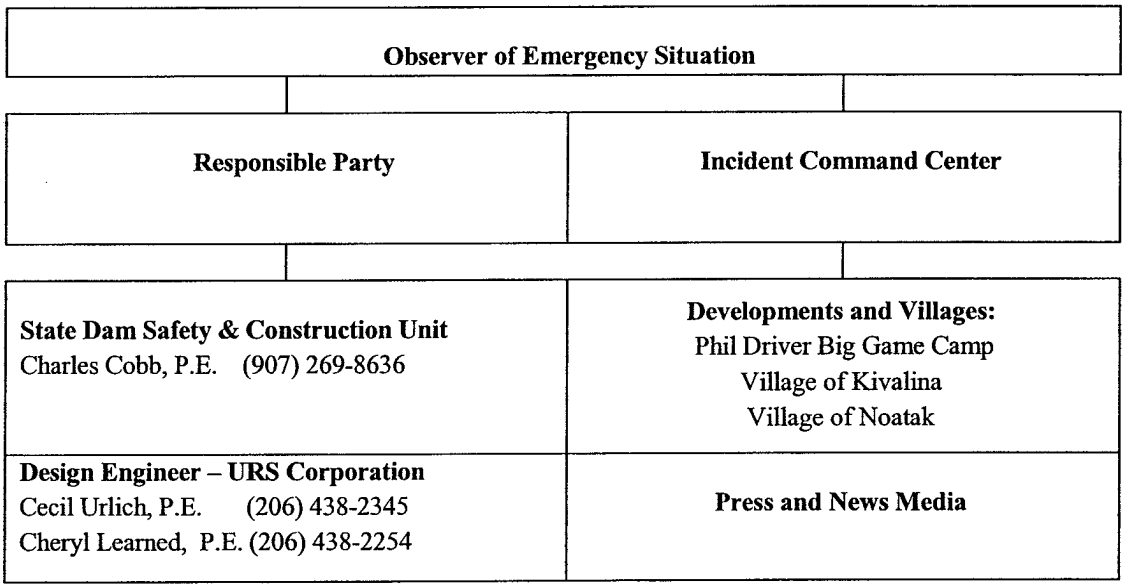
The control of information is critical because if others contact the press and news media first, then a distorted article could be published that could damage the public perceptions of the mine and of TCAK.

6.2.5 Failure in Progress

If failure is in progress, an evacuation of the potential downstream inundation area must be started immediately in accordance with the following:

- Remove any workers who might be downstream of the dam
- Keep workers out of the impacted area except as allowed by the ICC
- Modify operation plan so as not to worsen failure
- Implement the emergency situation notification flowchart

EMERGENCY SITUATION NOTIFICATION FLOW CHART



6.2.6 Failure is Imminent

If failure of the dam is imminent, but has not started, the following steps should be initiated immediately:

- Remove any workers who are not authorized by ICC downstream of the dam
- Keep workers out of the impacted area except as allowed by the ICC
- Modify operation plan so as not to increase the chances of failure
- Take preventive actions described in Section 6.2.11 of this plan
- Implement the emergency situation notification flowchart.

6.2.7 Slowly Developing Failure or Unusual Situation

If there is a slowly developing failure, where failure is not imminent, but could occur if no action is taken, or unusual situation has developed, the Responsible Party should:

- Notify ICC of the potential problem and keep them advised of the situation
- Contact State Dam Safety Engineer (Charles Cobb, P.E.) at (907) 269-8636
- Contact URS Design Engineers (Cecil Urlich, P.E. or Cheryl Learned, P.E.) at (206) 438- 2700
- Ask these contacts if there are immediate actions to be taken to reduce the risk of failure
- If necessary, implement preventive actions described in Section 6.2.11 of this plan.

6.2.8 Possible Emergency in Progress or Imminent Conditions

Some, but not necessary all, of the events which can lead directly to the failure of the dam are listed in the sections below. A brief summary of the emergency situation is presented in each section, followed a brief outline of actions to be taken to stabilize the situation.

6.2.8.1 Pond Water 2 feet below Tailings Main Dam Crest

Due to high precipitation and runoff into the tailings impoundment, the water in the reservoir is 2 feet below the crest of the dam and is rising.

Implement the procedures in Section 6.2.6 - **Failure is Imminent**.

6.2.8.2 Tailings Main Dam Cresting

Due to high precipitation and runoff collection from the mountains surrounding the tailings impoundment, the level of the reservoir crests the tailings main dam and water overflows to the seepage collection dam.

Implement the instructions in the Section 6.2.5 - **Failure in Progress.**

6.2.8.3 Tailings Main Dam Failure

Uncontrolled release of water from the tailings main dam will result during the main dam failure. Failure of the main dam would result in release of water into the seepage collection dam resulting in possible failure of the seepage collection dam.

Implement the instructions in the Section 6.2.5 - **Failure in Progress.**

6.2.8.4 Seepage Collection Dam Cresting

Due to high precipitation or excess seepage from the main tailings impoundment, the water in the seepage collection dam is cresting.

Implement the instruction in the Section 6.2.6 **Failure Imminent** procedures.

6.2.8.5 Seepage Collection Dam Failure

Uncontrolled release of water from the seepage collection dam will result during the seepage collection dam failure. Failure of the seepage collection dam would result in release of water into Red Dog Creek.

Implement the instructions in the Section 6.2.5 **Failure in Progress.**

6.2.9 Possible Slowly Developing Failure Conditions

Some possible slowly developing failure conditions may include, but are not limited to: erosion, slumping, sloughing, or cracking of the dam or abutment; new springs, seeps, sandboils, sinkholes, or increased leakage; and, landslides. Appropriate responses to these situations follow.

6.2.9.1 Erosion, Slumping, Sloughing, or Cracking of the Dam or Abutment

If unusual erosion, slumping, sloughing or cracking is observed in either the dam or abutment areas, then a determination must be made of the location, size of the affected area(s) (height, width, and depth), severity, estimated seepage discharge, clear or cloudy seepage, and the reservoir and tailwater elevation.

If failure appears likely, immediately implement the Section 6.2.6 - **Failure is Imminent** procedures; otherwise, contact the Dam Safety and Construction Unit and the URS design engineers.

6.2.9.2 New Springs, Seeps, Sandboils, Sinkholes, or Increased Leakage:

If new springs, seeps, sandboils, or sinkholes are observed, or if there is a rapid increase in the underdrain flow, a determination must be made of the location and size of the affected area, estimated discharge, nature of discharge (clear or cloudy), and impoundment and tailwater water elevations. A map of the area will be helpful to illustrate where the problem is located.

If failure appears likely, implement the Section 6.2.6 - **Failure is Imminent** procedures; otherwise, report all findings to the Dam Safety and Construction Unit and URS design engineers.

6.2.9.3 Landslides:

Any landslide having the capability to rapidly displace large volumes could generate large waves that would move across the impoundment. A geologist must make determinations of the size, possible cause, degree of effect on the operation, probability of additional movement of the disturbed area and other slides area, development of new slide areas, and anything else that seems important.

All landslides should be reported to the Dam Safety and Construction Unit.

6.2.10 Possible Unusual Occurrences

6.2.10.1 Earthquake

The occurrence of an earthquake of at least Richter Magnitude 5.0 (M 5.0) in the vicinity of the mine will require that actions be taken. An M 5.0 event will be felt by site personnel as follows:

"Felt by all. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., knocked off shelves. Furniture moved or overturned. Weak plaster and masonry cracked. Trees, bushes shaken visibly, or heard to rustle."

The following action items are required:

- Immediately conduct a general overall visual inspection of the dam
- If the dam is failing, implement the Section 6.2.5 - **Failure in Progress** procedures
- If the dam is damaged to the extent that there is flow downstream, implement the Section 6.2.6 - **Failure is Imminent** procedures
- Check the dam crest for settlement, and if it has dropped by more than 0.5 feet, contact the URS Design Engineers and State Dam Safety Engineer
- If damage has occurred but is not judged serious enough to cause failure of the dam, observe the nature, location and extent of the damage, evaluate the potential for failure and contact the URS Design Engineers and the State Dam Safety Engineer
- Photograph and describe any new or increased slides, sloughs, seepage, and subsidence, and document the location, extent, rates, effects on adjoining structures, springs or seeps, reservoir elevation, prevailing weather conditions, and other pertinent observations
- If there appears to be no imminent danger of dam failure, the Responsible Party should thoroughly inspect the following
    - both faces of the dam for cracks, settlement, or seepage
    - drains and seeps for any turbidity, muddy water, or increased flow
    - reservoir and downstream areas for landslides

6.2.10.2 Human Interference (Terrorism, Vandalism or Accident)

Human interference could occur as terrorist activity, vandalism or accident. The nature and form of human interference is hard to predict. If such interference is suspected to have occurred, take the following steps:

- Immediately conduct a general overall visual inspection of the dam
- If the dam is failing, implement the Section 6.2.5 - **Failure in Progress** procedures
- If the dam is damaged to the extent that there is flow passing downstream, immediately implement the Section 6.2.6 - **Failure is Imminent** procedures.
- Check the dam crest for settlement. If the dam crest has dropped by more than 0.5 feet, contact the URS Design Engineers and the State Dam Safety Engineer
- If damage has occurred, but is not judged serious enough to cause failure of the dam, observe the nature, location, and extent of the damage, evaluate the potential for failure and contact the URS Design Engineers and the State Dam Safety Engineer
- Photograph and describe any new or increased slides, sloughs, seepage, and subsidence, and document the location, extent, rates, effects on adjoining structures, springs or seeps, reservoir elevation, prevailing weather conditions, and other pertinent observation.

- If there appears to be no imminent danger of dam failure, Responsible Party should thoroughly inspect the following:
    - both faces of the dam for cracks, settlement, or seepage
    - drains and seeps for any turbidity, muddy water or increased flow
    - reservoir and downstream areas for landslides

6.2.11 End of Emergency Situation and Follow-up Actions:

Once conditions indicate that there is no longer an emergency at the tailings main dam site and the URS design engineers and the State Dam Safety and Construction Unit have found the dam to be safe, the Responsible Party should contact the ICC to terminate the emergency situation.

6.2.12 Reporting of Incidents:

The Responsible Party must report by telephone to the Dam Safety and Construction Unit on any condition affecting the safety of the tailings main dam or when the incident has occurred. This call must be made as soon as practical after the condition is discovered or following any incident.

6.2.13 Preventive Actions to be Taken

The following actions describe some of the steps that could be taken at the tailings main dam to prevent or delay failure after an emergency is first discovered. These actions should only be performed under the direction of URS design engineers and with the concurrence of the State Dam Safety and Construction Unit.

6.2.13.1 Overtopping by Flood Waters:

- Stop discharging tailings into the impoundment.
- Place sandbags along the dam crest to increase freeboard.
- Protect the dam slopes by placing erosion resistant materials over eroding areas.
- Divert incoming floodwaters around the impoundment areas, if possible.

6.2.13.2 Reduction in Freeboard (less than 2 feet) and/or Loss of Dam Crest Width:

- Place additional riprap or sandbags in damaged areas to prevent further erosion.
- Lower the water level, by pumping or siphoning, to below the damaged area.
- Restore freeboard with sandbags or earth and rock fill.
- Continue close inspection of the damaged area until the storm is over.

6.2.13.3 Slide of the Upstream or Downstream Slope of the Embankment:

- Restore lost freeboard by placing sandbags or filling in the top of the slide.
- Stabilize slides on the slope by weighting the toe area with soil, rock, or gravel.
- Lower the water level at a safe rate and elevation by pumping or siphoning
- Cease operation until repairs are made.

6.2.13.4 Erosional Seepage or Leakage (Piping) Through the Embankment, Foundation, or Abutments:

- Plug the flow with available material (hay bales, bentonite, tailings, or plastic)
- Lower the water level until the flow decreases to a non-erosive velocity or stops.
- Place sand and gravel over the exit area to hold material and allow drainage
- Place the sand and gravel as an inverse filter with the finer material placed first
- Continue to lower the water level until a safe elevation is reached.
- Cease operations until repairs are made.

6.2.13.5 Mass Movement of the Dam on Its Foundation (Spreading or Mass Sliding Failure):

- Immediately lower the water level until excessive movement stops.
- Continue lowering the water level until a safe level is reached.
- Cease operations until repairs are made.

6.2.13.6 Excessive Settlement of the Embankment:

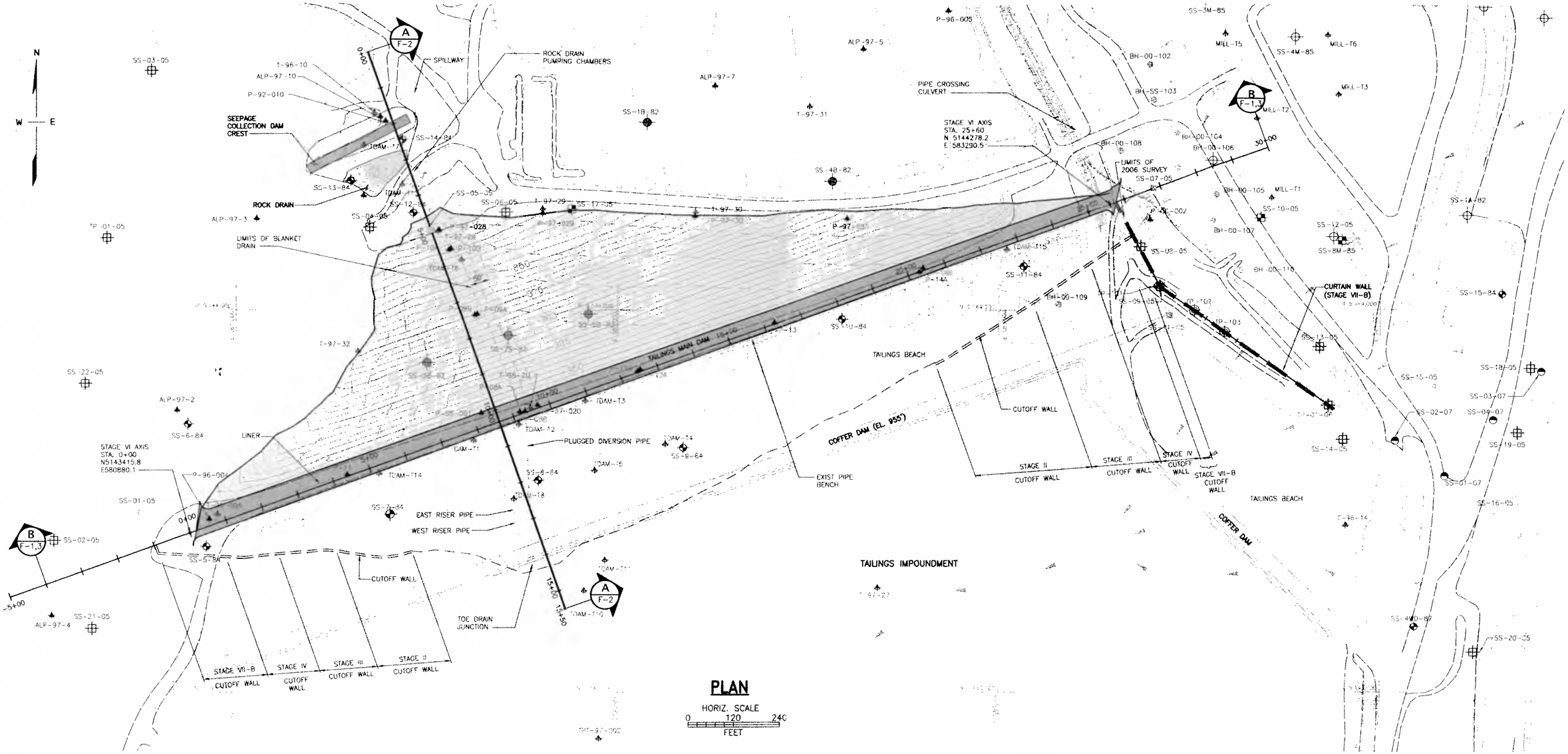
- If necessary, restore freeboard, preferably by placing sandbags.
- Lower the water, by pumping or siphoning, to a safe level.
- Cease operations until repairs can be made.

6.2.14 Supplies and Resources

In an emergency situation, personnel, equipment and supplies might be needed on short notice. The table below lists the supplies and indicates how to access them.

Item	Contact	Location
Earthmoving Equipment	Mine Department	Red Dog Mine
Sand and Gravel	Mine Department	Red Dog Mine
Sandbags	Warehouse	Red Dog Mine
Pumps	Mine Department	Red Dog Mine
Pipe	Mine Department	Red Dog Mine
Laborers	Mine Department	Red Dog Mine
Other	Mine Department	Red Dog Mine

DRAWINGS



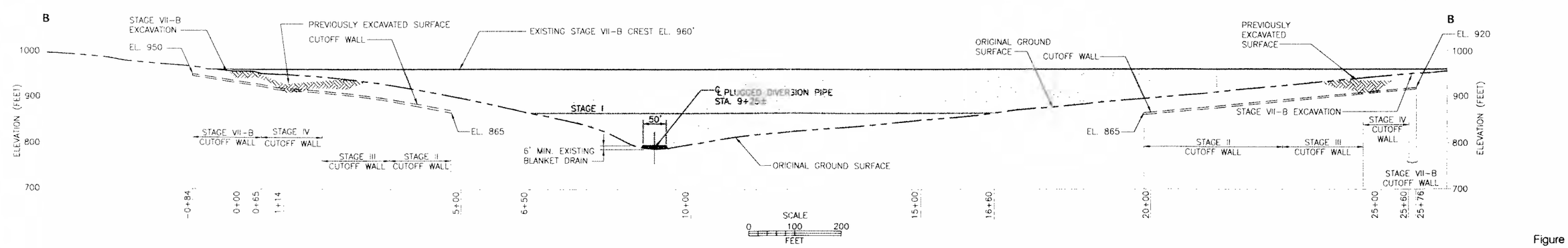


Figure 1

Existing Stage VII-B Dam Plan & Profile

Operation and Maintenance Manual
Red Dog Mine, Alaska

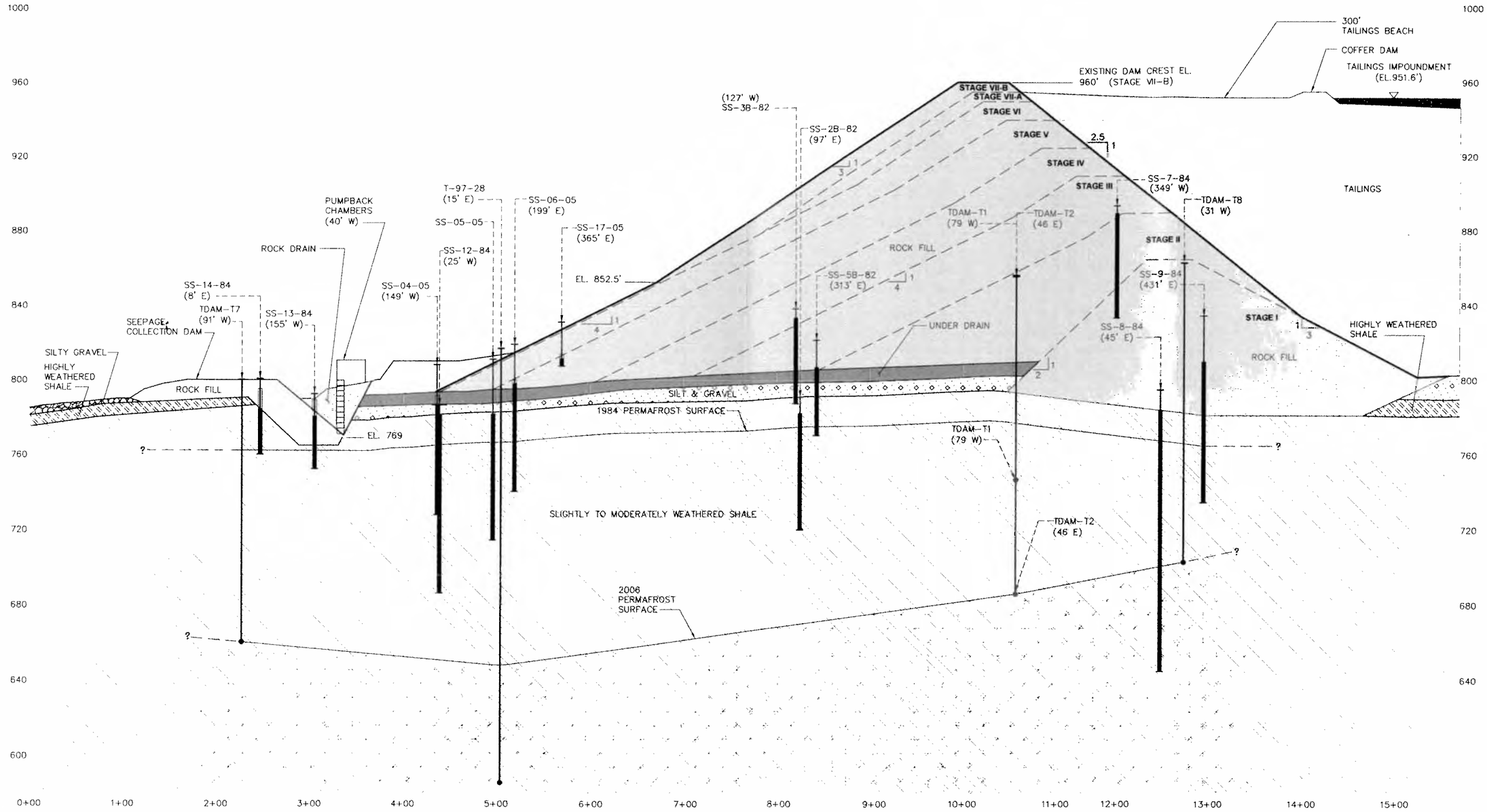
Job No. 33755331

URS

P:\ACAD\PROJECT\TeckCominco\Alaska\OPERATION MAINTENANCE MANUAL\F-1.dwg Dec 17, 2007 - 2:41pm

NORTHWEST

SOUTHEAST



KEY:

BORING: GROUND SURFACE; SOIL; HIGHLY WEATHERED BEDROCK; BEDROCK

PIEZOMETER/THERMISTOR: SURFACE ELEVATION; TIP ELEVATION

LEGEND

PERMAFROST IN 2006

SLIGHTLY TO MODERATELY WEATHERED SHALE

SUBSURFACE PROFILE
STATION 8+60

(A / F-1)

HOR. SCALE 0 50 100 FEET

VER. SCALE 0 25 50 FEET

NOTE

1. DEPICTS THE UNDERDRAIN, WHICH IS ACTUALLY OFF-SET INTO THE PAGE ALONG ALIGNMENT ≈ 76FT ON AVERAGE. (A / F-1)
2. PERMAFROST SURFACES ARE APPROXIMATE AND INTERPOLATED FROM BORINGS AND THERMISTORS.

P:\ACAD\PROJECT\TeckCominoAlaska\OPERATION MAINTENANCE MANUAL\F-2.dwg Dec 17, 2007 - 2:40pm

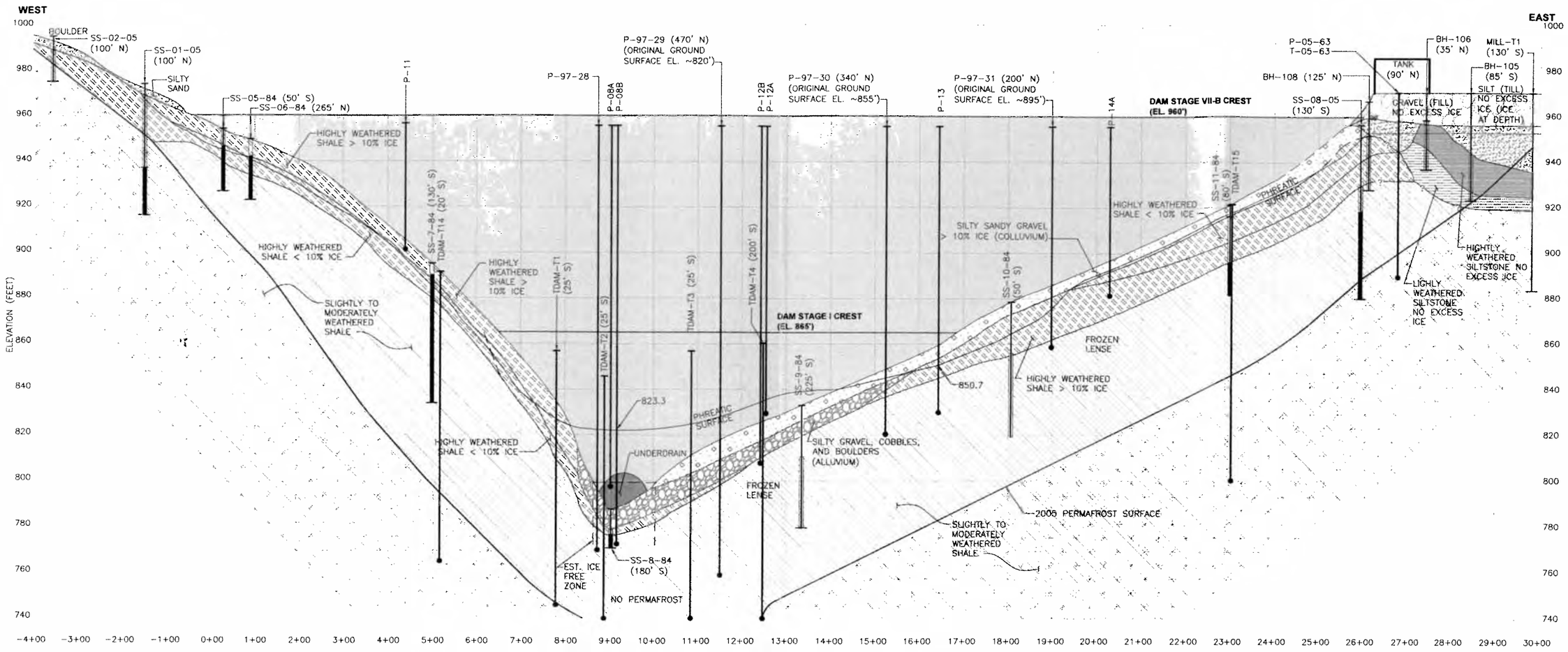
Job No. 33755331

URS

Figure 2

Profile along Highest Main Dam Section

Operation and Maintenance Manual
Red Dog Mine, Alaska



PROFILE ACROSS EMBANKMENT CREST

B
F-1

100 0 100 200
HORIZONTAL SCALE IN FEET

20 0 20 40
VERTICAL SCALE IN FEET

LEGEND

- PERMAFROST IN 2005
- SLIGHTLY TO MODERATELY WEATHERED SHALE

KEY:

BORING: GROUND SURFACE; SOIL; HIGHLY WEATHERED BEDROCK; BEDROCK

PIEZOMETER/THERMISTOR: SURFACE ELEVATION; TIP ELEVATION

NOTES:

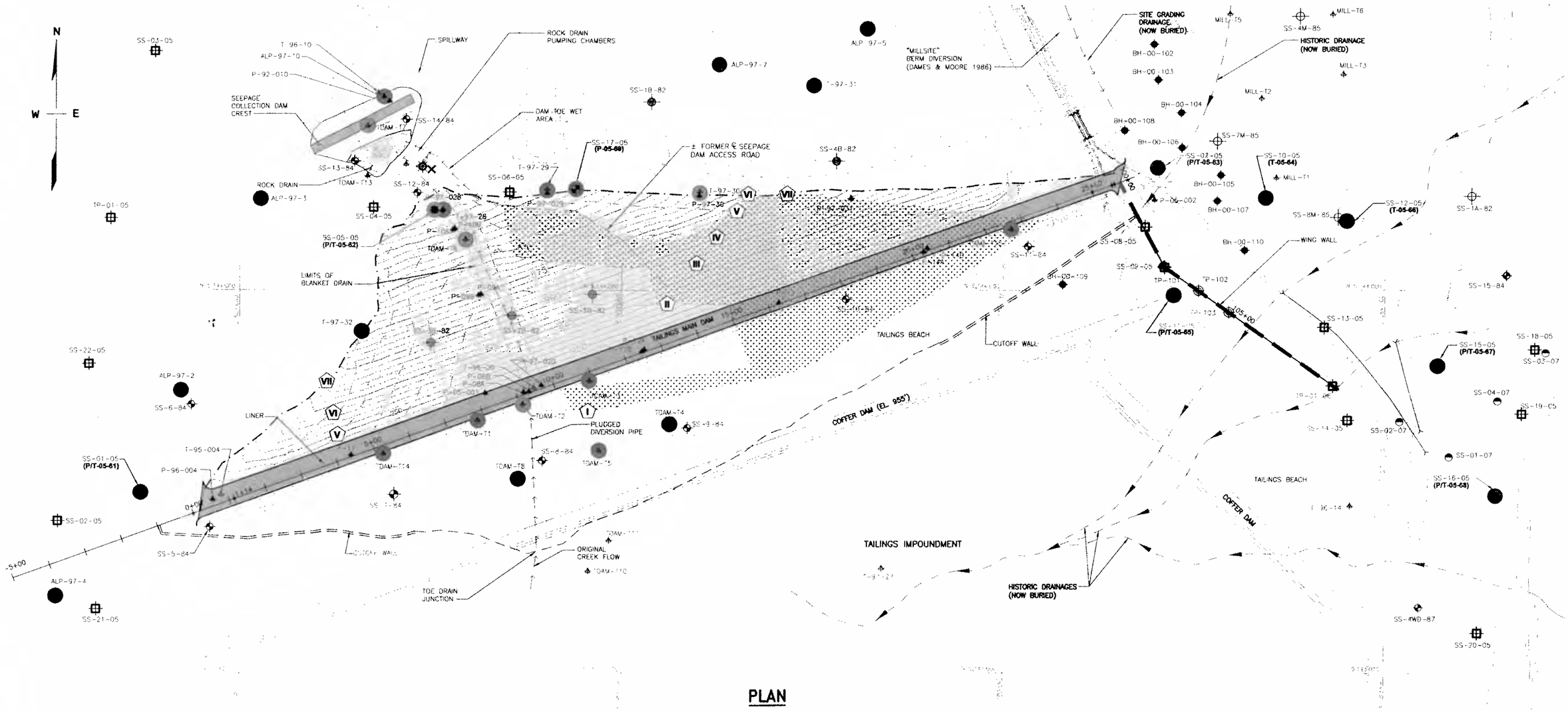
1. INDICATED SUBSURFACE DESCRIPTIONS REPRESENT GENERAL SOIL AND ROCK CONDITIONS UNDER DAM (BORINGS BY DAMES & MOORE IN 1982 AND 1984), UNDER WASTE STORAGE AREA (BORINGS BY DAMES & MOORE IN 1984 AND 1987), IN MILL AREA NEAR RIGHT ABUTMENT (BORINGS BY EBA IN 2000) ON RIGHT ABUTMENT (TEST PITS BY PND IN 2004), AND UNDER FUTURE DAM RAISES (URS, 2005).
2. ICE PERCENTAGES SHOWN BENEATH THE DAM WERE CALCULATED BY VOLUME PRIOR TO DAM CONSTRUCTION AND TAILINGS DISPOSAL. THESE PERCENTAGES DO NOT REFLECT CURRENT CONDITIONS. THE PERMAFROST AND FROZEN LENS LOCATIONS SHOWN ARE BASED ON CURRENT CONDITIONS AS DESCRIBED IN NOTE 4.
3. SOIL AND ROCK PROFILES SHOWN REPRESENT URS INTERPRETATION OF DATA FROM GEOTECHNICAL INVESTIGATIONS INDICATED IN NOTE 1. SUBSURFACE CONDITIONS ARE ONLY KNOWN AT BORING LOCATIONS AND MAY DIFFER AT OTHER LOCATIONS, ESPECIALLY IN THE RIGHT ABUTMENT AREA WHERE THEY ARE DISCONTINUOUS AND VARIABLE.
4. PERMAFROST PROFILES, ICE LENSES, AND PHREATIC SURFACE SHOWN REPRESENT TECK COMINCO INTERPRETATION OF THERMISTOR AND PIEZOMETER INSTRUMENTATION DATA. CONDITIONS ARE ONLY KNOWN AT THE INSTRUMENTATION LOCATIONS, AND MAY DIFFER AT OTHER LOCATIONS. WATER LEVELS SHOWN WERE COLLECTED THROUGH DECEMBER 2006.
5. MODIFY CONSTRUCTION AND EXCAVATION DEPTHS AS DIRECTED BY ENGINEER TO ACCOUNT FOR ACTUAL SOIL, ROCK, AND ICE CONDITIONS.

P:\ACAD\PROJECT\TeckCominco\Alaska\OPERATION MAINTENANCE MANUAL\F-3.dwg Dec 17, 2007 - 2:40pm

Job No. 33755331

URS

Figure 3
Profile across Embankment Crest
Operation and Maintenance Manual
Red Dog Mine, Alaska



PLAN

HORIZ. SCALE
0 120 240
FEET

LEGEND

- DAMES & MOORE FOR TAILINGS DAM (1982)
- DAMES & MOORE FOR TAILINGS DAM (1984)
- DAMES AND MOORE FOR WASTE STORAGE (1984 & 1987)
- EBA ENGINEERING FOR MILL FACILITIES (2000)
- PND FOR RIGHT ABUTMENT WING WALL (2004)
- PIEZOMETERS (PRE-2005)
- THERMISTORS (PRE-2005)
- URS WITH PIEZOMETERS & THERMISTERS (2005)
- URS WITH EITHER PIEZOMETERS OR THERMISTERS (2005)
- URS WITH NO INSTRUMENTATION (2005-2006)
- SEEP DISCHARGE FROM UNDERDRAIN
- LOCATION OF ELECTRICAL CABINET ON SIDE OF CONNEX
- NEW CULVERT LOCATION (APPROXIMATE, TCAK 2006)
- CULVERT (OLD LOCATION)
- DOWNSTREAM TOES OF STAGE I TO STAGE VII RAISES
- CURRENT DAM EXTENT (2006)
- SATURATED SURFACE AREA
- PERMAFROST PRESENT AT DEPTH BELOW SURFACE
- NO PERMAFROST TO DEPTH OF INSTRUMENTATION, ACTIVE LAYER ONLY

P:\ACAD\PROJECT\TeckCominoAlaska\OPERATION MAINTENANCE MANUAL\F-4.dwg Dec 17, 2007 - 2:41pm

Job No. 33755331

URS

Figure 4

Surface and Subsurface Conditions

Operation and Maintenance Manual
Red Dog Mine, Alaska

APPENDIX A

DAILY AND WEEKLY/QUARTERLY INSPECTION SHEETS

EMS Daily Dam & Pumping Inspection Sheet

Visual Tailings Dam and Seepage Pond Inspection

EMS DAILY DAM & PUMPING INSPECTION SHEET

Date: _____ **Name:** _____ **Temperature** **General Weather Condition** _____

Overburden Diversion System

Check condition of all pumps & piping as well as roads	Operating		Lines Intact		Berms Intact		Spills	
	Yes	No	Yes	No	Yes	No	Yes	No
	☐	☐	☐	☐	☐	☐	☐	☐

Comment _____

RedDogCreekPumpback & Dam

Surfaces checked for; cracks, leaks and slumps	Crest	Toe		East Buttress	West Buttress	Downstream Slope	Upstream Slope
	☐	☐		☐	☐	☐	☐

Auxiliary pump operating		Water Level (high/low)	Number of Pumps Avail.	
Yes	No		Grunfos	Bibo
☐	☐			

Comment _____

Tailings Dam

Surfaces checked for; cracks, leaks and slumps	Crest	Toe		East Buttress	West Buttress	Downstream Slope	Upstream Slope
	☐	☐		☐	☐	☐	☐

Comment _____

Seepage Dam

Surfaces checked for; cracks, leaks and slumps	Crest	Toe		East Buttress	West Buttress	Downstream Slope	Upstream Slope	Water level (high/low)
	☐	☐		☐	☐	☐	☐	

Comment _____

Freshwater Dam

Surfaces checked for; cracks, leaks and slumps	Crest	Toe		East Buttress	West Buttress	Downstream Slope	Upstream Slope
	☐	☐		☐	☐	☐	☐

Comment _____

APPENDIX B

PIEZOMETER DATA COLLECTION

OPERATION AND MAINTENANCE PROCEDURES

Standard Operating Procedure for
Obtaining Readings from Geokon Vibrating
Wire Transducers Read at Central Tenninal Panels

Equipment
1 Geokon GK - 403 Readout box 1
54ead patch cord
1 Piezometer data collection form 1
Pencil

Procedure:
- Drive to Airstrip.
- Read and record (on the data collection form) both barometer readings located in the control tower. This should be done immediately before or after reading the piezometer.

Drive to the central terminal panel by the seepage pond (at toe of tailing dam) or at the central terminal panel located at the west end of the tailing dam crest. Open the fiberglass enclosure that protects the central terminal panel.

Connect the 10-pin Bendix connector on the patchcord to the socket on the readout box labeled "Transducer.

Connect the five color-coded alligator clips of the patch cord to the color-coded terminal posts on the central terminal panel. The alligator dips and terminal colors are:

Red - Positive vibrating wire lead
Black - Negative vibrating wire lead
White - Negative thermistor lead
Green - Positive thermistor lead
Blue - Shield

- Select position B using the "Display" knob on the GK-403.

Turn on the GK-403 by pulling the on/off toggle switch toward you.

- Set the two knobs on the central terminal panel to read position #1.
- Read and record both temperature (°C) and transducer units (digits) on the piezometer data collection form.

Repeat for the other active switch positions. The switch positions and the corresponding piezometer numbers are indicated on the inside of the switchbox door.

- Turn off the readout box.

Disconnect the leads.

- Secure the cover on the waterproof fiberglass enclosure that protects the central terminal panel.

– PROCEDURE FOR READING IN-PIT PIEZOMETER DATA AND DOWNLOADING THE GEOKON GK-403 READOUT BOX

– Collecting Piezometer Data

- NOTE:
  * You must read the T-Dam Baro along with the piezometers each day.
  * You will read P99-038 twice on the day you do the Week 3 readings, storing it in Row 3/Column 19 and **in** Row 5/Column 45.

Collecting ALP data

- Place the M-Scope probe in the well and note the depth to conductance. The depth should be measured from the top of the steel casing.
- Write the depths **in** the field book.

– Place the Geokon switch in position `G'. In this position, the Geokon will store data into **a** 2D array that has 256 columns and 256 rows. Each piezometer is designated by its own column, with each row a different reading for that piezometer. In the case of these piezometers, the readings are grouped in Row 5. This facilitates the downloading process and confines the data to a row not used for the monthly readings. The sequence of column numbers and piezometer names is shown at right.

Row_ #	Column #	Piezometer name	Packer (psi)
5	45	P99-038	-
	46	P99-043	-
	47	P99-044A	-
	48	P99-044B	-
	49	P99-045	-
	50	P99-047	-
	51	P99-048	-
	256	T-Dam Baro	-

– To take a reading for a specific piezometer, scroll to the row designated for that week and the column designated for that particular piezometer. Use the joystick to change columns (F-) and rows (T ~). The piezometer name should show in the center of the Geokon display, for example "ID: P99-043". It is important that the row number stays the same for each piezometer in the group being read. The Geokon displays the reading that is currently in the array for that setting under the heading "MEM" and the reading that it is receiving under the heading "NOW". When you are satisfied that you are at the correct piezometer and in the correct row, push the `select/store' button to record the data.

– Repeat this for all the piezometers. Once you have read all of them, download the GK-403 in the office following the Transferring the Data directions below.

Transferring the Data

– Plug the PC cable into the RS-232 terminal on the Geokon box. The cable should be connected to the COM1 port on the PC. Do NOT turn on the Geokon at this time (this is important).

– Start the "DownloadPiezo" option in the "Thermistor & Piezo" menu, this will delete the old `dat.csv' file, if it exists, and start Procomm. Hit the `page down' key to get into download mode. A dialog box opens and prompts for a download format, type `7' for ASCII. It then prompts for a file name, type the date as the file name in the form **pzMMDDYY.csv,** eg. **pz072599.csv,** and enter.

– Send the data. Turn the Geokon box on and push the `menulescape' button, the first option is `send data', make sure it is highlighted and push `select/store' to select. The next option is what you want to send, choose `Row' and push `select/store', it then asks for a start and stop row. The start row should be the row you were using, Row 5 (unless you've changed it on screen 1), so push `select/store'. When the numbers on the PC screen stop scrolling, the download is finished.

– Hit the `Esc' key to have Procormn shut down the communication link, then hold down the `Alt' key and type `x' to exit Procomm, a message will **ask** if you want to exit to DOS, type `Y'. Next Excel will start up and a message will ask if this is a monthly reading, type `N', the next message will ask for the name of the file, type it in the same as before, i.e. **pzMMDDYY.csv** format. The file will open, the screen will blink, the numbers in the third column will change to the actual collection date, and then Excel will close.

– Erase the data from the Geokon. First push the `menu/escape' button until the "Main Menu" appears. The second option is `clear data', make sure it is highlighted and push `select/store' to select. The next option is what you want to clear, choose `Row' and push `select/store', it then asks for a start and stop row. The start row should be the row you were using, Row 5 (unless you've changed it on screen 1), so push `select/store' and the row is cleared_

– Turn off the Geokon box and disconnect the cables.

APPENDIX C

THERMISTOR DATA COLLECTION

OPERATION AND MAINTENANCE PROCEDURES

Standard Operating Procedure for Obtaining Thermistor String Readings

Equipment:

1 "Thermistor Well Data" form
1 Pencil
1 Fluke multimeter with leads (Fluke model 23, Series II)
1 Dryden Instrumentation Switchbox
1 #2126 Master padlock key

Procedure:

- Drive to well.
- Unlock and remove the protective cap.
- Pull excess thermistor cable from well casing.
- Remove dust cover from the 50 pin male plug on cable end.
- Connect the leads to the multimeter by pushing the black lead into the port labeled "com" and the red lead into the port labeled "Ω" (ohms).
- Connect the red and black leads from the multimeter to the red and black terminal posts on the switchbox.
- Turn on multimeter by turning the main selector switch to "Ω" DC.
- Meter should read 0.00.
- Push toggle switch on switchbox to "Test" position.
- Record the reading displayed on the multimeter on the Thermistor Well Data form. The reading should be very close to the number stamped on the faceplate of the Dryden switchbox (16325 Ω). (Because the multimeter is an auto-ranging type it may read 16.32 or 16.33 KΩ). If the multimeter does not display something close to this reading then the multimeter is too cold. (See operating range for the multimeter in the owner's manual). Warm the multimeter and try again. You may wish to change the battery in the multimeter.
- Turn right toggle to "read" position.
- Turn left toggle to "1 - 12" position.
- Turn selector switch to "1" position and read and record the reading on the "Thermistor Well Data" form.
- Repeat process for switch positions 2 - 12.
- Turn toggle switch to "13 - 24" position.
- Continue to read and record data for positions 13 through 24.
- Take another reading in the test position and record. Again, this reading should be similar to the reading stamped on the faceplate of the switch box.
- Make sure the well number, date, time, outside air temperature and the name of the operator are on the form.
- Turn off the multimeter and disconnect leads.
- Install dust cover on the 50 pin connector plug.
- Carefully coil the excess cable back into the well casing.
- Lock the protective cap back into place.

Transferring the Data

1. Connect the PRO2000 data collector's COM1 port to the PC's COM 2 port. (Make certain you plug it in to the correct port, it is the plug used for the HP48, not the one for the GPS.)

On the PC

2. Start PCS by clicking the "Juniper Transfer" icon in the "Mine survey_engineering" menu, or by doing the following:
   Open a DOS window (located under Programs).
   Type "CD C:\THERMS\PCSIDE", hit enter.
   Type "SET OMNIDIR=C:\THERMS\PCSIDE", hit enter.
   Type "PCS", hit enter.
3. Hit F5 to enter the data transfer setup menu.
4. Select "COM 2" by hitting F1.

On the PRO 2000 hand held

5. Type "C:", enter, "CD \DOS", enter, and then "PS" and enter.
6. Select Drive "D:" from the list by hitting enter , using the arrow keys to find "D:", and hitting enter again. When selected, you should end up in "D:\THERMS".
7. Scroll to the file you want to transfer and hit the INS key to select the file.
8. Type F5 to get into data transfer mode.
9. Hit F4, 'RECEIVE', on the survey computer immediately before hitting F5, 'SEND', on the PRO 2000.
10. Repeat steps 7. to 9. selecting and transferring files from the PRO 2000.
11. Once finished, to exit from each program hit esc, then Y for Yes, and enter.
12. Transfer the downloaded data files in "C:\THERMS\PCSIDE", on the PC, to "Y:\Minetech\Inter\Monitor\Thermis\RawData" on the server computer.
13. When you are certain all the data files in the PRO 2000 have been transferred to the RawData directory on the Y: drive, delete them from the PRO 2000 by typing "DEL *.RDG" in the "D:\THERMS" directory.

Updating the Excel thermistor files

1. Start the Update Macro by clicking the "UpdateThermsXLS" icon in the "Mine survey_engineering" menu.
2. Type in the name of the thermistor rawdata file to be dumped, and enter.

Helpful Notes

1. To check battery status type "setup" and go to SYSTEM INFORMATION; if voltage is greater than 5.9V, charge should be OK. If the unit ever beeps during use, immediately save all data, get out of the T24 program, turn the unit off, and bring it inside to charge overnight before dumping the data to the PC.
2. If the data collector sits for a while without being used, it will shut off. To resume, hit the ON/OFF key and it will turn on at the same screen displayed when it shut off.
3. To change screen contrast up use the 'RED' & '+' keys and down use the 'RED' & '-' keys.
4. To turn on backlighting use the 'RED' & 'BS' keys.

STANDARD OPERATING PROCEDURE

FOR OBTAINING THERMISTOR READINGS WITH THE T5KMUX SYSTEM AUTOMATED THERMISTOR STRING READER

Introduction

The purpose of this system is to provide a method of automating the labor intensive reading of thermistors installed in strings. The system provides a handheld package that will record the ohmic values of the all the thermistors points on a string in a few seconds. These values are recorded on a handheld PC or laptop for later archiving on desktop platforms.

The system consists of the following :

Juniper Systems Pro2000 handheld computer (DOS PC-AT compatible)
including CA-2009 serial Pro2000 to PC cable, and PW-110T charger
Dryden Instrumentation T5KMUX analog to digital converter and multiplexor
Program diskette with T24.exe, MSTRTHRM.TXT, T24.cfg files

This documentation and the programs have been prepared for use with the Pro2000 because of it's field ruggedness but the T24 program and the T5KMUX unit should work on any PC DOS platform. You should be able to easily operate the program on a desktop for testing in the office or on a laptop in the field if conditions allow it.

Mstrtherm.txt One line for each thermistor string to be defined. The order will be the order that the selections appear in the pick list on Pro2000. The program checks that all thermistor strings have between 1 and 24 points and terminates the loading of the list if an invalid record is found. Each line is formatted as follows:

Char 1-8	String ID
Char 9	Space
Char 10-29	Location Description
Char 30-34	space
Char 35-36	Number of nodes (thermistors on the string)
Char 38-50	Excel spreadsheet name

Example Group :

```
MW95-T1   MAIN WASTE DUMP      7 dpmwthrm.xls
MW95-T2   MAIN WASTE DUMP      7 dpmwthrm.xls
T96-15    RED DOG CREEK       24 196th10.xls
T96-16    RED DOG CREEK       24 196th10.xls
T96-17    RED DOG CREEK       24 196th10.xls
T-8       TAILINGS DAM        17 tdamthrm.xls
T-15      TAILINGS DAM        13 tdamthrm.xls
```

If these files have been loaded, turn on the Pro2000, set the default dir to D:\THERMS and execute the T24 program from the DOS prompt. We set the PC Configuration options in T24 to Default video and used Com2 for the T5KMUX connection. Changing the PC Configuration options requires exiting back to DOS and restarting the program.

For training purposes, it helps tremendously to run the T24 program on a full screen desktop before using it on the Pro2000.

Transfer Data to DeskTop PC

The output files created by T24 have a default extension of *.rdg. These files will be transferred to the PC using the PolyShell utilities. See the Pro2000 Operators Manual

```
Here are two lines of example output file with a ruler line on top:
....|....1....|....2....|....3....|....4....|....5....|....6....|..
dpmwthrm.xls MW95-T1   7 09/14/97 19:04 Err 0  132225 132225 132225
132225 132225 132225 132225
tdamthrm.xls T-15     13 09/14/97 19:04 Err 0  15.205 11.509 132274
132274 132274 132274 132274 132274 132274 132274 132274 132274
132274
```

The values above (132225 or 132274 k ohms) were generated by T5KMUX sn002 when there was no thermistor connected to the T5KMUX. In a real case, the value files would be things like 16.325, 100.32, or -15.16 which would always fill the seven characters where you see the 132274. The 16.325 is in k ohms and is the table resistance value for a YS144007 thermistor at 0°C.

The error code at character 45 above means the following :

0=All ok as far as program is concerned

1=The program saw no signal from the analog to digital converter within 25msec after it was told to do a conversion. T5KMUX probably not connected to PC.

2=The internal control values used by the analog to digital converter appear out of range. Readings might be good nevertheless.

3=At least one value was outside of the 1k TO 20k check range. Sometimes this is just because nothing is connected or the thermistor has failed. In the case of a negative value, the program is telling you that the value drifted more than 5 counts in the two readings taken about 2 seconds apart. This could be caused by moisture intrusion into the thermistor potting or cable or might indicate a the presence of electrical noise. The typical symptom of moisture intrusion is when measured with an ohmmeter, you see if just keep moving in one direction approaching some value slower and slower the longer you hold the meter on the point.

APPENDIX D

DATA COLLECTION DEVICE

INSPECTION, CALIBRATION, AND MAINTENANCE PROCEDURES

From Water Management Consultants "Quality Assurance Project Plan for the Hydraulic Characterization of the Tailings Impoundment", January 1998

B.4 Instrument inspection, calibration, and maintenance

B.4.1 Dryden switchbox and Fluke multimeter

The Dryden switchbox and Fluke multimeter shall be inspected for damage and proper function prior to use. The switchbox is subject to significant mechanical wear, so a backup unit should be available in case of failure of the primary unit. A record of repairs for all equipment must be maintained in the log books.

Each thermistor string was tested in an icebath by Dryden Instrumentation prior shipment. The results of the icebath calibrations are presented in appendices of Phase I and subsequent reports. The calibration data are used in equations to reduce the data to temperatures. Each thermistor string is tested a second time prior to installation to confirm proper function of the string. No other calibrations are required. A calibration check is required immediately before and after each thermistor string reading. When the Fluke model 23, Series II meter is turned on, with the Dryden switch box in the off position, it should give a reading of 0.00. When the switch box is set to the "TEST" position it should give a reading matching the resistance shown on the switch box (16325 Ω or 16.32 or 16.33 KΩ). After reading all of the thermistor nodes, a "TEST" reading is taken again. If actual readings differ from these values, the thermistor data are invalid. Erroneous readings may be due to excessive cold or a low battery. It is the responsibility of mine personnel to correct the problem and take the readings again. Unstable thermistor readings must be noted in the log book. Unstable readings may be due to poor connections, a faulty switchbox, or shorting of the thermistor string. All corrective actions and repairs must be noted in the log book.

B.4.2 Electronic well sounder

Electronic well sounders must be inspected for function and damage prior to each usage and shall be periodically (at least annually) calibrated against a new sounder or tape. Calibration must include a zero and a span check. The correction factor (if any) must be applied to subsequent measurements and indicated as such in the log book. Field conditions that prevent measurement of water levels with the required degree of precision shall be noted in the log and appropriate corrective action taken and recorded in the log. A broken well sounder cable must be calibrated after repair, and the service recorded in the log. An example of a correction for a repaired well sounder with stretch using a linear regression is given below for the data in Table B-2.

Table B-2 Example of well sounder calibration data

	New sounder or tape reading (X)	Old sounder reading (Y)
1 (zero)	0.00	2.6
2 (span)	300.00	302.71

Corrected measurement = (Y3-Y1)/(Y2/(X2+Y1)), where Y3 is a new reading

or

Corrected measurement = (Y3-2.6)/(302.71/(300+2.6)) = (Y3-2.6)/1.000364

B.6.1 Data recording

Prior to each routine data acquisition event (thermistor and piezometer measurements), a checklist is prepared by the designated Cominco team leader. The checklist indicates sites to be monitored, the date of measurement, and the team member that carried out the data collection. Data are recorded on the forms in Appendix A or in dedicated bound field books. If dedicated bound field books are used, all data shown on the forms must be recorded. When all of the data have been collected, the data sheets are copied and forwarded to the Cominco Project Manager or directly to the WMCI Project Manager for processing.

Data collected include the following:

- resistance measurements from site thermistors,
- manual measurements of depth to water within open screened wells,
- measurements of "digits" representing electrical impulses from vibrating wire transducers, and
- subpermafrost groundwater samples for age.

B.6.2 Data transformation

Both thermistor and vibrating wire transducer measurements require transformation prior to use in site analyses. Thermistor data consist of resistance measurement which are converted to representative temperatures by the following general equation:

$$T = 1/(A + B(\ln R) + C(\ln R)^3) - Y - 273.15$$

where:

T	=	temperature (C°)
A,B,C	=	empirical correction coefficients, (0.0012807, 0.000268, 9.073×10^{-6})
R	=	measured resistance (Ω)
Y	=	temperature bias correction based on icebath calibration

This equation has been programmed into spreadsheets for use by mine personnel, and in an Microsoft Access database kept by WMCI as the overall project database (Section B.6.4). Calibration sheets for each thermistor string installed are kept on file at WMCI, and will be reported in the various Groundwater Monitoring Program phase reports.

APPENDIX E

VERTICAL TURBINE PUMPS

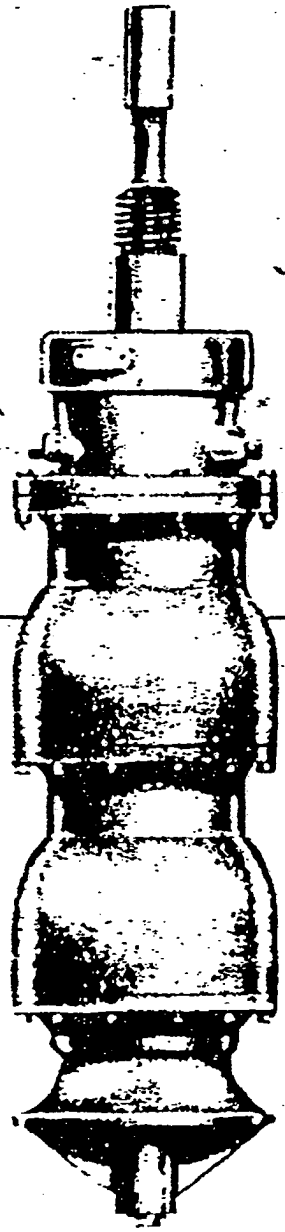
INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

7000

VERTICAL TURBINE PUMPS

6004-1501-01



Fairbanks Morse

NOTICE

CAUTION

IMPORTANT SAFETY NOTICE

THE INSTALLATION, USE AND OPERATION OF THIS TYPE OF EQUIPMENT IS AFFECTED BY VARIOUS FEDERAL, STATE AND LOCAL LAWS AND THE REGULATIONS CONCERNING OSHA. COMPLIANCE WITH SUCH LAWS RELATING TO THE PROPER INSTALLATION AND SAFE OPERATION OF THIS TYPE OF EQUIPMENT IS THE RESPONSIBILITY OF THE EQUIPMENT OWNER AND ALL NECESSARY STEPS SHOULD BE TAKEN BY THE OWNER TO ASSURE COMPLIANCE WITH SUCH LAWS BEFORE OPERATING THE EQUIPMENT.

STORAGE OF PUMPS

IF THE EQUIPMENT IS NOT TO BE INSTALLED AND OPERATED SOON AFTER ARRIVAL, STORE IT IN A CLEAN, DRY, WELL-VENTILATED PLACE, FREE FROM VIBRATION, MOISTURE, AND RAPID OR WIDE VARIATIONS IN TEMPERATURE. ROTATE THE SHAFT SEVERAL REVOLUTIONS. (NOT TO EXCEED EVERY TWO WEEKS) TO:

1. COAT THE BEARINGS WITH LUBRICANT,
2. RETARD OXIDATION OR CORROSION AND,
3. PREVENT POSSIBLE FALSE BRINELLING.

FOR OIL LUBE BEARINGS FILL THE RESERVOIR FULL OF OIL FOR STORAGE. DRAIN OIL TO THE PROPER LEVEL FOR START-UP. ROTATE THE SHAFT PERIODICALLY, ALSO NOT TO EXCEED EVERY TWO WEEKS.

CONSIDER A UNIT IN STORAGE WHEN:

1. IT HAS BEEN DELIVERED TO THE JOB SITE AND IS AWAITING INSTALLATION.
2. IT HAS BEEN INSTALLED BUT OPERATION IS DELAYED PENDING COMPLETION OF PLANT CONSTRUCTION.
3. THERE ARE LONG (30 DAY OR MORE) PERIODS BETWEEN OPERATION CYCLES.
4. THE PLANT (OR DEPARTMENT) IS SHUT DOWN.

NOTE: STORAGE REQUIREMENTS VARY DEPENDING ON THE LENGTH OF STORAGE, THE CLIMACTIC ENVIRONMENT AND THE EQUIPMENT. FOR STORAGE PERIODS OF THREE MONTHS OR LONGER, CONTACT THE MANUFACTURER FOR SPECIFIC INSTRUCTIONS. IMPROPER STORAGE COULD RESULT IN NON-WARRANTY COVERED RESTORATION REQUIREMENTS OR NON-WARRANTY COVERED PRODUCT FAILURES.

Seller shall in no event be liable for delays caused by fires, acts of God, strikes, labor difficulties, acts of governmental or military authorities, delays in transportation or procuring materials, or causes of any kind beyond Seller's control. No provision for liquidated damages for any cause shall apply under this order. Buyer shall accept delivery within thirty (30) days after receipt of notification of readiness for shipment. Claims for shortages will be deemed to have been waived if not made in writing within ten (10) days after the receipt of the material in respect of which any such shortage is claimed. Seller is not responsible for loss or damage in transit after having received "In Good Order" receipt from the carrier. All claims for loss or damage in transit should be made to the carrier.

TITLE & LIEN RIGHTS: The equipment shall remain personal property, regardless of how affixed to any realty or structure. Until the price (including any notes given therefore) of the equipment has been fully paid in cash, Seller shall, in the event of Buyer's default, have the right to repossess such equipment.

PATENT INFRINGEMENT: If properly notified and given an opportunity to do so with friendly assistance, Seller will defend Buyer and the ultimate user of the equipment from any actual or alleged infringement of any published United States patent by the equipment or any part thereof furnished pursuant hereto (other than parts of special design, construction, or manufacture specified by and originating with Buyer), and will pay all damages and costs awarded by competent court in any suit thus defended or of which it may have and notice and opportunity to defend as aforesaid.

STANDARD WARRANTY: Seller warrants products of its own manufacture against defects in materials and workmanship under normal use, and service for one (1) year from date of installation or startup, but not more than eighteen (18) months after date of shipment. Accessories and components not manufactured by Seller are warranted only to the extent of the original manufacturer's warranty. Notice of the alleged defect must be given to Seller in writing with all identifying details including serial number, type of equipment and date of purchase within thirty (30) days of the discovery of same during the warranty period. Seller's sole obligation on this warranty shall be, at its option, to repair or replace or refund the purchase price of any product or part thereof which proves to be defective as alleged. No allowances will be made for repairs or alterations effected without specific written authorization from Seller.

If requested by Seller, such product or part thereof must be promptly returned to the manufacturer prior to any attempted repair; or sent to an authorized service station designated by the manufacturer. All shipping expenses are to be prepaid by the buyer. Seller accepts no responsibility for loss or damage in transit of goods, nor will any warranty claim be considered unless the returned goods are received intact and undamaged as a result of shipment. Repaired or replaced material returned to customer will be shipped F.O.B. the manufacturer's factory.

Seller warrants repaired or replaced parts of its own manufacture against defects in materials and workmanship under normal use and service for ninety (90) days or for the remainder of the warranty on the product being repaired. This warranty applies to the repaired or replaced part and is not extended to the product or any other component of the product being repaired.

Under the terms of this warranty, Seller shall not be responsible nor liable for:

a. Consequential, collateral or special losses or damages.
b. Equipment conditions caused by fair wear and tear, abnormal conditions of use, accident, neglect, or misuse of said equipment.
c. Labor charges, loss or damage resulting from the supplying of defective part(s) or improper repairs by unauthorized person(s).
d. Damage caused by abrasive materials, chemicals, scale deposits, corrosion, lightning, improper voltage or mishandling.

Seller reserves the right to substitute new equipment and/or improve the part(s) on any equipment judged defective without further liability. All repairs and/or services performed by Seller, not adjusted as covered by this warranty, will be charged in accordance with the current equipment and service prices.

This warranty is VOID unless the purchaser provides protective storage, installs and maintains the equipment in accordance with manufacturer's instructions.

Credit will NOT be allowed nor shipment accepted on any part(s) or equipment returned unless prior approval in writing has been obtained.

THIS WARRANTY IS THE SOLE WARRANTY OF SELLER AND ANY OTHER WARRANTIES EXPRESS, IMPLIED IN LAW OR IMPLIED IN FACT, INCLUDING ANY WARRANTIES OF MERCHANTABILITY AND FITNESS FOR USE, ARE HEREBY SPECIFICALLY EXCLUDED.

No employee of the Seller and no agent, dealer or distributor has any authority to change or enlarge the terms of this warranty to obligate the Seller to other than strictly the terms of this written warranty.

LIABILITY LIMITATIONS: Under no circumstances shall the Seller have any liability for liquidated damages or for collateral, consequential or special damages or for loss of profits, or for actual losses or for loss of production or progress of construction, whether resulting from delays in delivery or performance, breach of warranty, negligent manufacture or otherwise. The aggregate total liability of Seller in connection with the performance of this order, whether for breach of contract or warranty, negligence, indemnity or otherwise, shall in no event exceed the contract price. Buyer agrees to indemnify and hold harmless Seller from all claims by third parties in excess of these limitations.

Since the compliance with the various Federal, State and Local laws and regulations concerning occupational health and safety and pollution are affected by the use, installation and operation of the equipment and other matters over which the Seller has no control, the Seller assumes no responsibility for compliance with those laws and regulations, whether by way of indemnity, warranty or otherwise.

INSTALLATION

Upon receipt of your shipment, unpack and inspect all parts and assemblies carefully to make certain that none of the parts are missing or damaged. If any parts have been damaged during shipment, report your findings immediately to the transportation company involved, giving full details. During this inspection, all parts should be thoroughly cleaned and any burrs removed by filing. The pump bowl assembly, including the line shaft coupling, is normally shipped completely assembled. Both the suction and discharge openings should be inspected for damage and for intrusion of foreign materials. The shaft should rotate by hand, and should be moved in and out to check for end play. Place all parts in an orderly arrangement for convenient assembly.

All shafting has been pre-straightened to a tolerance of .005" in 10 feet prior to leaving the factory or assembly plant. Care in handling must be taken to insure that the shafting is not bent prior to and during installation.

WARNING: Read this complete manual and manuals for all component equipment before assembly is started. Failure to properly assemble this unit may cause damage to the equipment and possible injury to personnel.

If storage is required see Page 3 for requirements.

Foundation

A foundation must be supplied consisting of any material that will provide a permanent, rigid support. This support should be of sufficient size and depth to fully carry the weight of the pump (full of water) and rigid enough to prevent vibration.

Concrete foundations should be built level and on solid ground. Properly sized anchor bolts are to be supplied and should be cast in pipe sleeves two and one-half times the diameter of the bolt.

When the pump is to be mounted over a pit on structural steel framing, it should be located as close to the main structure or wall as possible. Cross members should be used to prevent distortion and vibration of the structural mounting frame.

Well and Pit Inspection

Before installation is started the well or pit must be cleaned of all loose material and debris. **CAUTION:** Reduced performance and possible equipment damage may result if the pit or well is not properly cleaned.

Suction Pipe and Strainer

A. If a suction pipe and strainer are to be used, thread the strainer into the strainer pipe coupling.

B. Lift the suction pipe assembly over the well and lower this assembly until the pipe clamp is resting on the foundation. Clean and lubricate the exposed threads.

Bowl Assembly

NOTE: Before proceeding, measure and record the pump bowl assembly end play. This information will be needed later.

CAUTION: The 7000 series bowl assembly may be shipped with two pipe plugs threaded into the discharge bowl. (See Fig. 1) If this is an enclosed line shaft installation (either brass or wood lined) these pipe plugs must be removed. Failure to remove the plugs will cause water to enter the enclosing tube and leak out at the discharge head. Bearing failure may result.

A. Attach a pipe clamp to the upper portion of the bowl assembly and carefully lift the assembly over the opening.
CAUTION: Careless handling and bumping may disort or break the bowl assembly.

At this point, if a suction pipe is used, thread the bowl assembly onto the suction pipe. Tighten the assembly with a strap or chain wrench. Remove the suction pipe clamp.

B. Lower the assembly until the pipe clamp is resting on the foundation.

C. Clean and lubricate the discharge head, column, enclosing tube, and shaft coupling threads.

Column and Shafting

CAUTION: All joints must be properly cleaned, deburred and firmly seated. Any misalignment of these joints may cause vibration and/or excessive bearing wear.

NOTE: All Column threads, including oil tube, should be coated with (non-hardening) Permatex #2 during installation.

A. Column With Enclosed Line Shaft-Brass Bearings

(1) When the line shaft is smaller than the basic pump shaft size, the pump shaft is turned down so a standard straight shaft coupling can be used. This combination may require the first five foot section of enclosing tube to be oversized. In this case, a stepped connector bearing is threaded into this tube which will accept the standard size tube.

(2) When the line shaft is larger than the basic pump shaft a stepped shaft coupling is required. A stepped tube connector bearing may also be required. Both of these special parts will be assembled on the pump bowl assembly.

(3) Remove the end plugs from the ends of the assembled tube shaft assembly. Slide the shaft out of the tube about one foot. Insert this assembly into the first column section leaving about one foot of tube and two feet of shaft extending out of the column end that does not have the column coupling.

(4) Using a rope, make two half hitches around the line shaft, two around the tube, and two half hitches around the column. (See Fig. 10) (Other methods may be used to support the tube and shaft during assembly, but make sure they can carry the load and will not damage or distort the parts.)

(5) Position a column clamp just below the coulmn coupling. **NOTE:** Be sure the column clamps have a smooth square surface for the column coupling to rest on. An irregular surface may cause coupling distortion.

FIG. 13 - Method of tightening tube joint

FIG. 14 - Showing proper method of tightening column coupling. By properly attaching chain tongs, the column pipe will not be dented or damaged.

The following general procedures are noted:

On "C" and "D" style heads, when the last column section is 10 foot or longer, DO NOT mount the head on the column nor use the head lifting lug to hold the unit during assembly. The lifting slings may disengage from the open lifting lug hooks during this procedure.

On heads with lifting lugs DO NOT mount the driver before the head is assembled to the column.

on "C", "D", and "F" heads, the column flanges are relieved so the air vent holes are open. Be sure to properly align the flange on the head.

A. Standard Flange — All Head Styles

Standard Column — Enclosed Line Shaft

(1) Build up the top enclosing tube assembly using standard tube sections, except the last section which is the top enclosing tube. This tube is slightly longer than the standard tube and has an extra deep internal thread on one end. This section must be assembled so the "long threaded end" projects into the head.

(2) Thread the column to head flange onto the column, until the column seats against the flange. Tighten this assembly.

(3) Insert the tube and shaft assembly into the column with the shaft and tube extending out of the threaded end of the column as previously described. Be sure the top tube is positioned at the flanged end of the column.

(4) Use the tope to hold the tube and shaft. Lift up the assembly and position over the unit in the well, using a column clamp located at least two feet below the column flange.

(5) Assemble this to the unit as previously described in the column section. Lower the unit until it rests on the column clamp.

(6) Lightly coat the column flange with grease and position the column gasket.

(7) Using cable slings on the discharge head lifting lugs, position the head over the unit.

Warning: Use a guide rope going from the sling joint, above the head, attached to the discharge flange. This will keep the head from tipping over, possibly causing personal injury. Lower it to within 1/4" of the flange, taking care not to bump the shaft or tube. Rotate the head until the flange reliefs are lined up with the air vent holes; then insert the flange cap-screws Slowly lower the head until it rests fully on the flange, being sure the flange register is located inside the head. Tighten down all the flange bolts.

(8) Lift the entire assembly, using the head lifting lugs, and remove the column clamp. Rotate head into the required position and lower onto the foundation, and remove the sling.

Standard Column — Open Line Shaft

Follow the same procedure outlined for standard column — enclosed line shaft, except there is no enclosing tube used.

Stub Column — Enclosed Line Shaft

(1) With the last full section of column, tube, and shaft positioned in the well, thread the top shaft into the last line shaft coupling. Tighten with pipe wrenches.

(2) Thread the top tube onto the existing enclosing tube. On wood lined tubing, the top tube will have inside threads on one end and outside threads on the other which go into the wood line tube coupling. On brass bearing tubing, the top tube has inside threads on both ends, one of which has longer threads. Thread the short threaded end onto the tube connector bearing leaving the long threads up.

(3) Turn the head upside down and lightly grease the flange surface. Position the flange gasket and the flange, making sure the air vent holes are open. Bolt the flange to the head.

(4) Thread the stub column into the flange until it seats against the flange. Tighten with pipe tongs.

(5) Turn the head over and lift into position using slings on the head lifting lugs.

WARNING: Use a guide rope from the sling joint above the head attached to the discharge flange. This will keep the head from tipping over, possibly causing personal injury.

Lower the head assembly over the unit taking care not to hit the top shaft. Thread the stub column into the column coupling. Tighten with pipe tongs.

(6) Lift entire unit with the lifting lugs and remove the pipe clamp. Rotate the unit into the proper position and then lower it to the foundation. Level the head using shims; bolt the unit to the foundation, and remove the lifting slings.

Stub Column — Open Line Shaft

Follow the same procedure outlined for Stub Column — Enclosed Line Shaft, except there is no enclosing tube involved.

B. Adjustable Flange — Open or Enclosed Line Shaft ("C" and "D" Heads Only)

The adjustable column flange should be used on pump

closed valve, an air release valve in the discharge line between the head and the valve is required. If not provided, air in the column will be forced into the prelubrication line cutting off the water flow.

The prelubrication tank should be sized approximately as follows: .05 gallons per inch of column diameter per foot of static level. The tank should be mounted so its outlet is well above the inlet tapping on the head.

Driver Installation

NOTE: Read the driver installation manual carefully before proceeding with mounting the driver to the head.

A. Hollow Shaft Motors

(1) Remove the motor cover and the motor coupling. Using the motor lifting lugs, lift the motor over the head and lower on to morot register. Center the motor on the male register.

NOTE: On enclosed line shaft installations, one motor bolt is to be used to mount the oiler.

(2) Temporarily bolt down the motor. At this point the pump shaft should be centered in the bore; mark the position farthest off center. Pick up shaft and rotate 180°; if the position farthest off center moves 180°, a possible bent top shaft is indicated and must be changed. If the position farthest off center remains approximately the same, the problem is alignment. To correct for misalignment or squareness, start by placing wedges under the discharge head base near the anchor bolts. Adjust wedge positions until the pump shaft is fairly centered. Final adjustment is made by placing shims between the motor and discharge head fit.

(3) Once the shaft is properly aligned, and discharge head should be grouted in place using any good grade non-shrinking grout. When partially cured, the base wedges should be removed and the voids filled with grout. Allow the grout to fully cure before proceeding.

(4) At this point, before the pump shaft is connected to the motor, make the motor connections per the manufacturer's instructions.

WARNING: Make sure the main power source is locked off before any electrical connections are made. After the bump start has been performed, again lock off the main power source to guard against accidental starting and electrical shock.

Bump start the motor to determine rotation.

NOTE: Rotation must be counter-clockwise as viewed looking down on the motor.

(5) Slip the motor coupling over the pump shaft and position into the motor register.

NOTE: If the motor clutch is not properly seated, vibration and possible bearing failure may occur. Insert the pump shaft key; this should be a slip fit. (File the key if necessary to obtain this slip fit.) Thread on the shaft adjusting nut. The unit is now ready for impeller adjusting.

B. Gear Drives

Read the gear manufacturer's instruction manuals carefully before starting installation. Installation is basically the same as that for hollow shaft motors. Read that section carefully. The engine or motor used to drive the gear is to be mounted on the same concrete foundation as the pump head; if not, a rigid shaft and coupling should not be used. If flexible shafting is used, install per manufacturer's instructions.

C. Solid Shaft Drivers

Mounting a solid shaft driver requires the use of a high ring base and an adjustable coupling.

(1) Mount the motor onto the high ring base, and bolt down.

(2) Slip the motor coupling, key and thrust collar onto the motor shaft, locking it in place with the set-screws.

(3) Position the pump half coupling onto the pump shaft, threading the adjustable section down as far as possible.

(4) Lift the motor and high ring base assembly onto the discharge head. Bolt the high ring base to the head.

(5) Using a dial indicator mounted on the motor shaft, indicate the pump shaft. The dial indicator reading should not exceed .002 TIR. Wedging under the discharge head, and moving the motor position on the head are methods used to correct the run-out.

Again, with the dial indicators mounted on the motor shaft, indicate the mating face of the pump coupling. This should be perpendicular to the motor shaft within .002 TIR. Adjust the motor with shims to correct excessive run-out.

NOTE: Corrections for one reading may throw out the other reading. Recheck both run-outs as one is corrected.

Once alignment is obtained, drill and ream for two dowel pins, both on the motor fit to the high ring base, and the fit of the base to the discharge head.

(6) Impeller adjustment is done by threading the middle piece of the coupling up and down on the pump shaft.

(7) At this point, uncouple the unit making sure the coupling cannot make contact. Per the motor manufacturer's instruction manual, perform all

Shaft Size	Threads Per Inch	Shaft Movement Based On Turns									
		1	2	3	4	5	6	7	8	9	10
1"	14	.07	.14	.21	.28	.36	.43	.50	.57	.63	.70
1-3/16"	12	.08	.17	.25	.33	.42	.50	.58	.67	.75	.83
1-1/4"	10	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
1-7/16"	12	.08	.17	.25	.33	.42	.50	.58	.67	.75	.83
1-1/2, 1-11/16"	10	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
1-15/16, 2-3/16"											
2-7/16"											

CAUTION: Do not let the unit get to full speed since this may cause the impellers to bottom out on the bowls, causing damage to the pump. Lower the shaft and again locate the position where the impellers just clear the bowl seats.
Mark the shaft and adjusting nut and proceed as follows:

b. L, H, and M – 7000 Series

With the impellers in their lowest position, lift the shaft up one turn of the nut. Turn the adjusting nut the correct number of turns required to lift the pump shaft the amount of shaft elongation calculated above.

Example: As previously calculated. Total Elongation = .032X2 + .27 = .33"
For a 1-11/16" diameter shaft, it would take 3-1/2 turns.

Therefore, the final adjustment on this unit would be 1 + 3-1/2 turns of 4-1/2 turns off the bottom.

c. HC, and MC – 7000

Check the total end play of the pump and divide this in half. Check this against the calculated shaft elongation. If the elongation is less than half the bowl end play, adjust the impellers as follows: Position the impellers midway in the bowls. Turn the adjusting nut the number of turns required to lift the impellers up a distance equal to the shaft elongation.

If the elongation is greater than one half the end play, adjust the impellers all the way up to their upper position. Then lower them one to two turns.

d. SHC – 7000

Adjust the impellers to their uppermost position and then lower two turns.

INITIAL START-UP AND OPERATING INSTRUCTION

Many variations may exist in both the equipment used with these pumps and in the pump's particular installation. Therefore, specific operating instructions are beyond the scope of this manual. However, there are some general and some specific rules that do apply. Adherence to these measures will help ensure the safe operation of the pump and avoid possible damage caused by improper operation.

Initial Start-Up

Inspect the complete installation to ensure that the installation instructions of this manual, and the manuals of all the related equipment, have been followed and that the installation is complete.

Ensure that the driver and gears are properly serviced, and that the proper pump rotation is obtained.

Rotate the pump shaft by hand. It should rotate freely on all motor driven installations.

On oil lubricated line shaft installation, open the lubrication valve and allow oil to feed into the tube for 10 minutes for each 100 feet of shafting. Initial lubrication should be 18 to 20 drops per minute for each 100 feet of shafting. After the first 6 hours of operation, reduce the flow rate to 6 drops per minute plus 3 additional drops for each 100 feet of shafting.

NOTE: Cold weather will cause the oil to thicken and reduce the flow rate. Feed adjustment should be checked with changing outside temperature.

Use a good grade of turbine or mineral oil with a viscosity rating of SAE #10. Detergent oils should not be used.

On water lubricated systems having a tank system, open the lube valve and allow one half in the tank to flow into the pump. At this point start immediately. Leave the valve open until the pump has refilled the tank. On water lubricated units with a pressurized prelubrication system, open the lube valve before the pump is started. Allow the water to flow one minute, plus 15 seconds for each 100 feet of shafting, before starting the pump. Do not shut off water supply until water is being pumped out of the discharge head.

If starting against a closed system or a closed discharge valve, be sure an air relief valve is installed between the pump head and the discharge valve or check valve.

If starting against an open system with a discharge valve, be sure the discharge valve is fully open.

MAINTENANCE

The equipment used with this pump should be maintained in accordance with the instruction manuals provided by the respective manufacturers.

Pump maintenance beyond routine oiling and packing adjustment and replacement will require at least partial disassembly.

Pump disassembly is basically the reverse of the assembly procedure previously described, except for bowl assembly. Refer to the bowl assembly section of this manual for assistance.

When replacing Lineshaft & Top shaft sleeves, in open lineshaft pumps, sleeves must be headed to 350-400° to break the Loctite bond. After the old sleeve has been removed, the shaft in the sleeve area should be properly cleaned to allow proper bonding surface for the new sleeve. Prior to new sleeve installation and after cleaning of the old bonding surface, the shaft must be checked for straightness since the heating of the sleeve will tend to warp the shaft. Shaft run-out should be .005" in each 10 ft.

When applying Loctite, care must be taken to insure that the entire surface on the shaft (were the sleeve is to be bonded) be covered with Loctite. The instruction card sent with the Loctite should be read carefully.

WARNING: Care should be taken in handling the shaft after heating to prevent personnel from being burned (wearing bestos glove, etc.).

WARNING: Never work on the pump or equipment without locking off the main power source to all equipment.

WARNING: Never use the motor lifting bolts to lift anything except the motor. These bolts or motor lugs are designed to carry only the motor weight.

NOTE: If it is found that any of the oil lube bearings have excessive year, it is recommenced that all the bearings be replaced (including bowl bearings).

PARTS ORDERING

When ordering spare or replacement parts for the Figure 7000 pump, the figure number, size, item number and serial number are required. Refer to the drawings and parts list in back of manual to be sure of the correct name and item number. Each part carries numbers and symbols that will be particularly helpful in ensuring that you receive the correct replacement part. Your order may be forwarded to your nearest Fairbanks Morse distributor or directly to the factory.

Returning Parts

All materials or parts returned to the factory must have prior approval and a Fairbanks Morse "Returned Goods Tag" to accompany them. Unnecessary delays and wasted efforts will be avoided by using the proper procedure in returning parts or equipment.

Contact your nearest Fairbanks Morse distributor listing the material to be returned and the reasons for the return. He will contact the factory to obtain approval for the return and to obtain the necessary "Returned Goods Tag" if the return is approved. You will be notified of the reasons if the approval is not given.

All material to be returned should be carefully packed to avoid damage in route from rough handling or exposure to weather. The "Returned Goods Tag" will give shipping instructions. All material to be returned freight prepaid unless otherwise instructed.

NOTE: WE RESERVE THE RIGHT TO CHANGE DESIGN AND SPECIFICATIONS OF PRODUCTS AT ANY TIME.

AN INTERCHANGEABLE OR ADAPTABLE PART, NOT IDENTICAL IN APPEARANCE, MAY BE SUBSTITUTED IF THE PART ORDERED HAS BEEN IMPROVED OR OTHERWISE MODIFIED.

This section contains descriptions and instructions which are the result of carefully conducted engineering and research efforts. It is designed for the safe and efficient maintenance of your pump. Failure or neglect to properly operate or maintain your pump may result in personal injury, property damage to the pump. READ THIS SECTION CAREFULLY.

INTRUDUCTION AND GENERAL DESCRIPTION

The Fig. 7000 Pump Bowl Assembly consists of four basic components i.e., the suction case, pump bowls, impellers, and discharge case. The number of stages or pump bowls in an assembly is determined by the head requirements of the individual installation.

The suction case serves as the intake for the pump bowl assembly. Liquid is moved by the impeller through the pump bowl where it is directed out of the bowl into the next stage bowl or the discharge. The bowls contain a bearing pressed into the bearing housing. Top bowls contain a bearing that extends up into the discharge case.

Impellers are connected to the pump shaft by split cone-shaped impeller lock collets.

The discharge case receives the liquid from the top bowl and directs it into the pump column pipe. The tapped holes in the external bosses of the discharge case provide venting of the pump discharge pressure when enclosed line shafts are used. This permits flow of lubricant down the enclosing tube. For open type pump shafts, these tapped holes are plugged, to prevent by-passing of the pumped liquid through the vent ports.

Uncrate the parts and inspect carefully to be sure nothing was damaged in shipment, especially the box of crated shafting. If any part has been damaged or broken in shipment, please report immediately to the factory and to the transportation company involved, with full particulars. Lay out the column pipe and bowl assembly on suitable timbers, with the coupling ends toward the well.

WEARING RINGS

PUMP SIZE	DIAM. CLEAR. NEW	MAX. DIAM. CLEAR. BEFORE RING RENEWAL
6M •	.016	.032
7M	.016	.032
8M	.016	.032
10M	.016	.032
10XH	.016	.032
11M	.016	.032
11H	.016	.032
12M	.016	.032
12MC	.012	.024
12HC	.012	.024
12XH	.012	.024
13H	.016	.032
14M	.016	.032
14MC	.012	.024
14XH	.016	.032
15H	.016	.032

TABLE 1

G. Cleaning and Lubrication

While the components are disassembled, lubricate all metallic bearings with clean grease or oil. Wipe off excess lubricant and apply anti-corrosive compound to all mating surfaces.

H. Assembly

The unit should be assembled in a reverse order of disassembly. See the parts drawing for reference to part numbers in the following steps.

Steps

1. Place Shaft Locating Tool into the end of the suction bell or case and place in a horizontal position using a suitable support.

2. Insert the pump shaft into the suction case and tighten the 3/8" Locating Tool Bolt until the shaft is securely fastened against the Positioning Plus.

3. Slide the sand collar down the shaft and turn back and forth until it fits fully down over the suction case bearing housing. Tighten the two set screws securely

4. Slide the impeller down the pump shaft until it rests in the top of the suction bell or case.

5. Using a screwdriver to open the split in the impeller collet, slide the collet down the shaft until it rests in the impeller. Push the collet into the impeller as far as possible by hand.

6. Drive the collet securely between the impeller and pump shaft, using the Impeller Lock Collet Driver. Remove collet driver.

7. Slide the pump bowl along shaft and then insert cap screws or screw bowl to suction case or bell. If threaded bowl, tighten with chain tong. Reposition the support.

8. Continue by repeating steps 5 through 7 until all of the bowls are assembled.

9. Slide the discharge case along the pump shaft. If threaded joints, screw by hand then tighten with chain tong. If flanged bowl, insert and tighten cap screws.

10. Remove the Shaft Locating Tool from bottom of the shaft on bell or case and replace with a threaded pipe reducer with a grease fitting.

11. Inject a good grade of insoluble grease into the fitting. Move the pump shaft back and forth several times to remove excess grease.

12. Remove the pipe plug and replace with the suction case plug.

13. After the pump bowl assembly is completely reassembled, measure projection and axial play of the pump shaft and compare with the measurement taken in step 2, paragraph C before disassembly.

IMPORTANT:

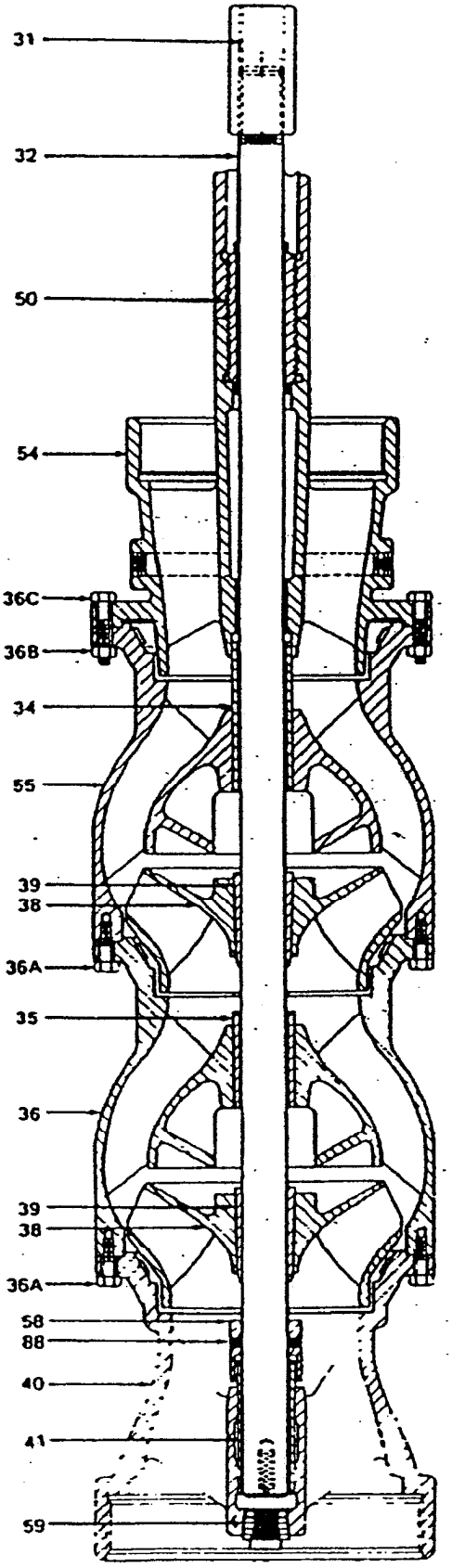
DISCHARGE CASE PLUGS ARE USED ONLY ON OPEN SHAFT PUMPS AND SPECIAL HIGH PRESSURE LUBE ENCLOSED SHAFT PUMPS.

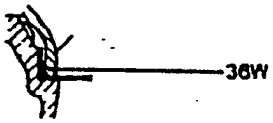
DO NOT USE PLUGS ON STANDARD ENCLOSED SHAFT PUMPS.

REPLACEMENT PARTS

An adequate inventory of spare parts is dependent upon the individual requirements of an installation. Consideration should be given to such variables as the extent of field maintenance anticipated, the severity of service conditions, the importance of minimizing downtime, and the number of units in service. In general, a spare for each moving part, bearing, or seal should be readily available in stock for possible replacement.

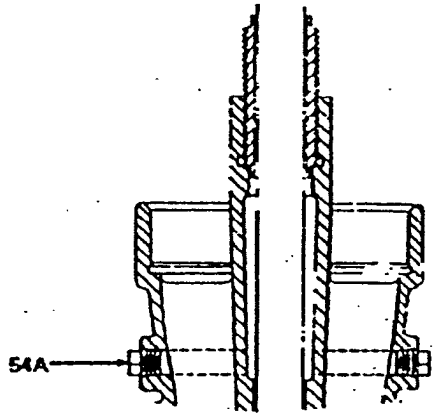
FIG. 1





BOWL WEAR RING

RUBBER BOWL BEARING



WATER LUBRICATION

THREADED JOINTS
ON 6M, 7M, 8M, 10XH

FIG. 3

WATER LUBE
OPEN LINE SHAFT

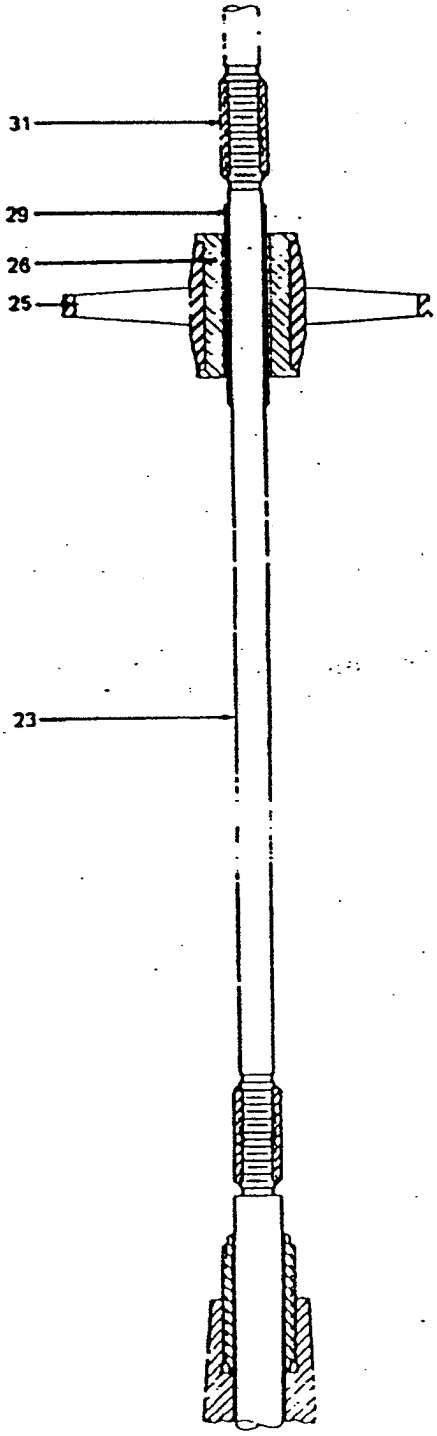


FIG. 5

WOODLINE
ENCLOSED LINE SHAFT

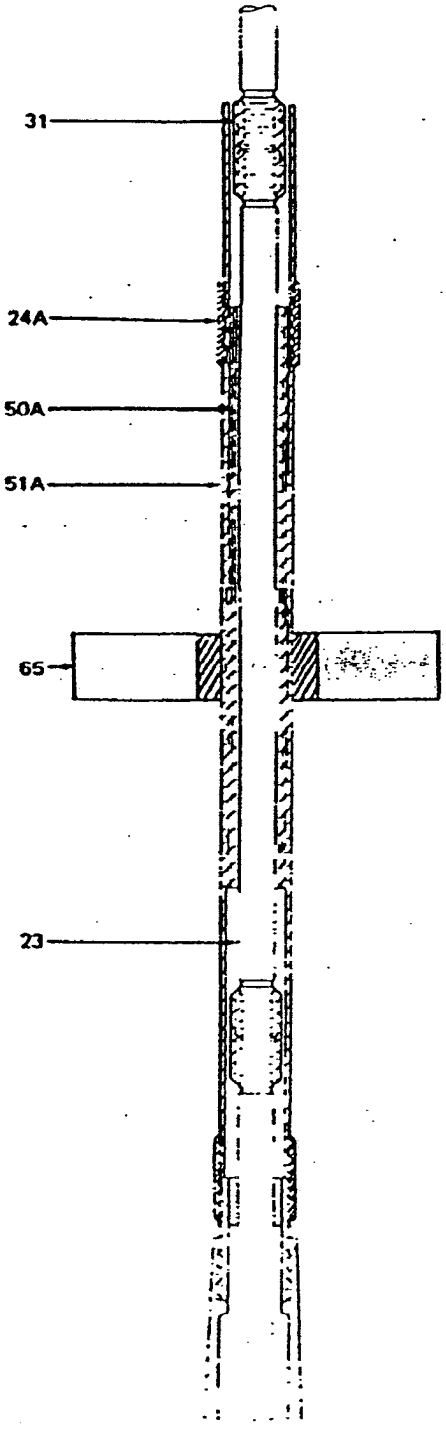


FIG. 4

BRASS
ENCLOSED LINE SHAFT

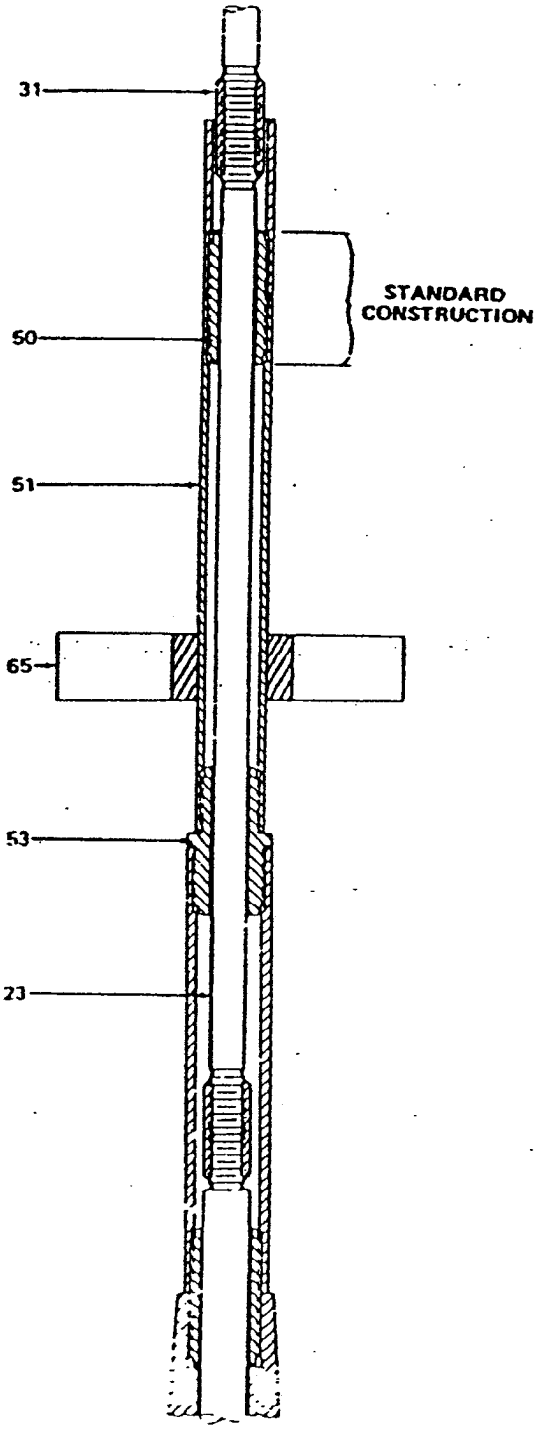
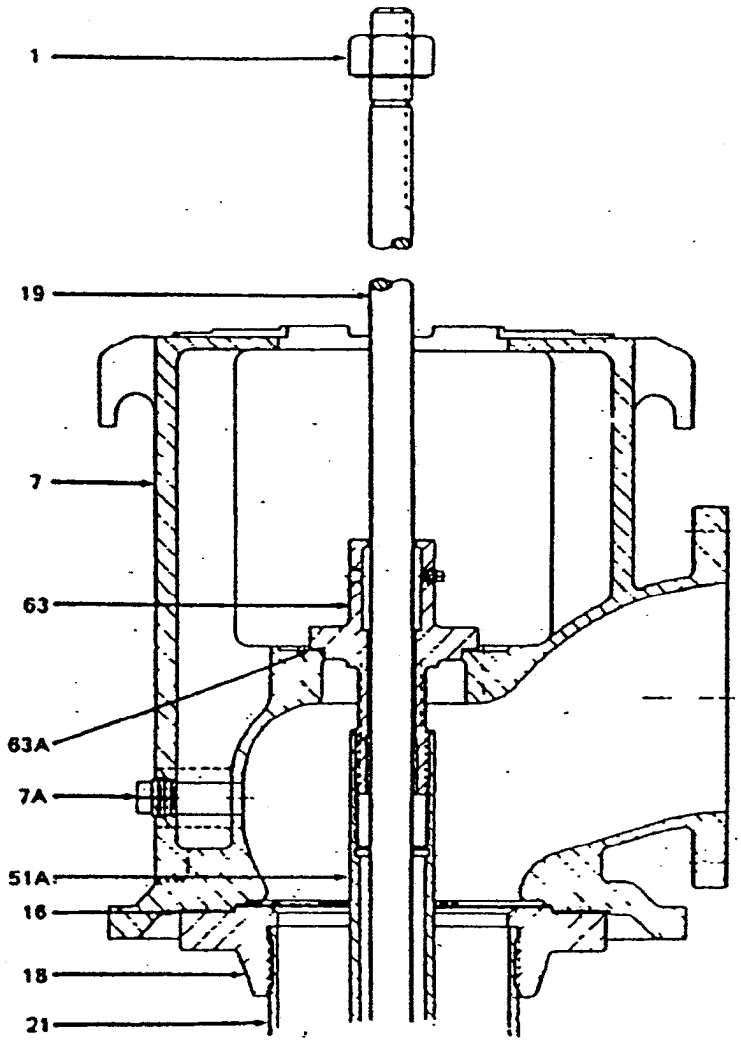
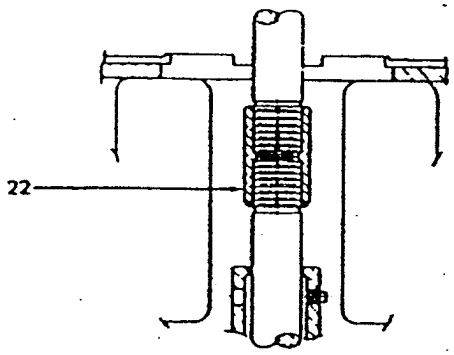
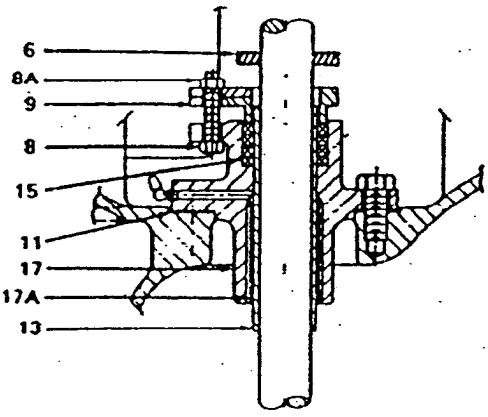


FIG. 6

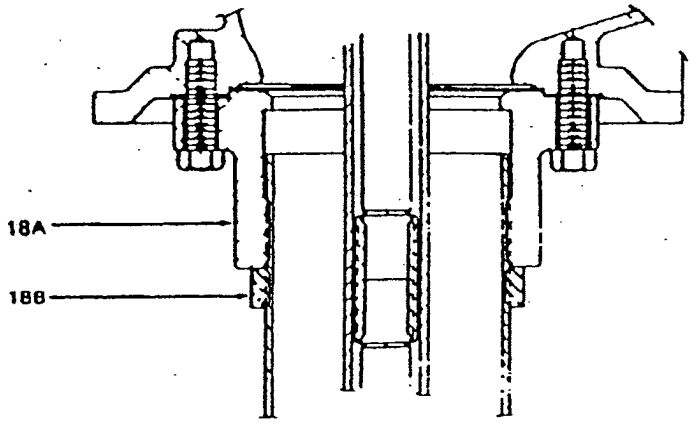




TWO PIECE TOP SHAFT
(12 X 4 SIZE REQUIRES HIGH RING BASE)

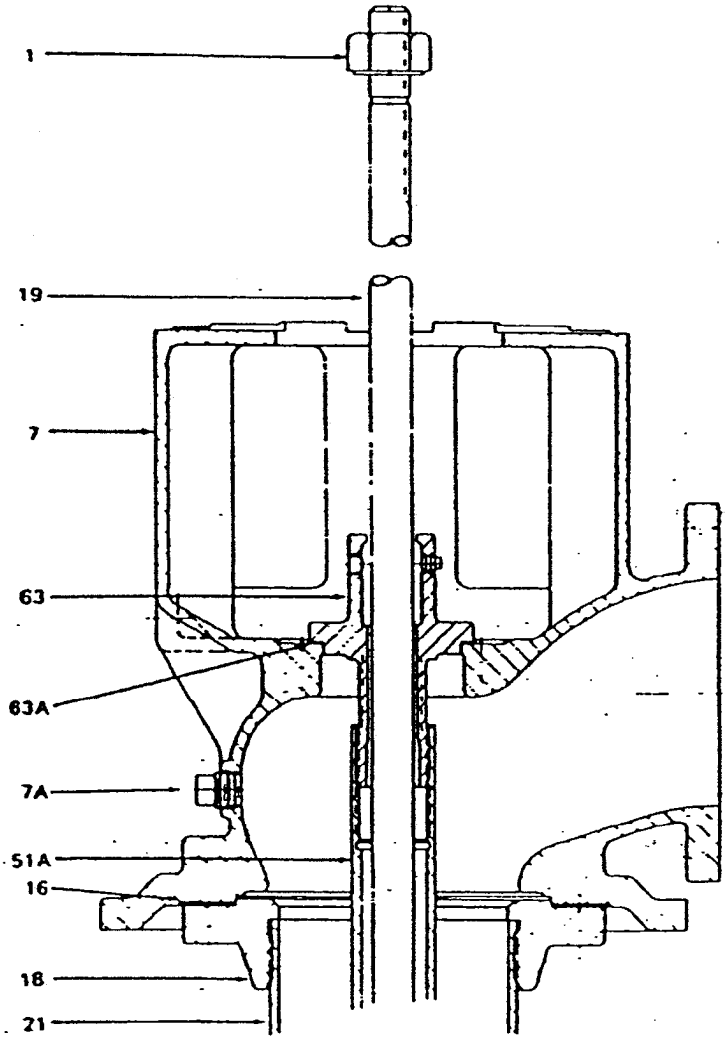


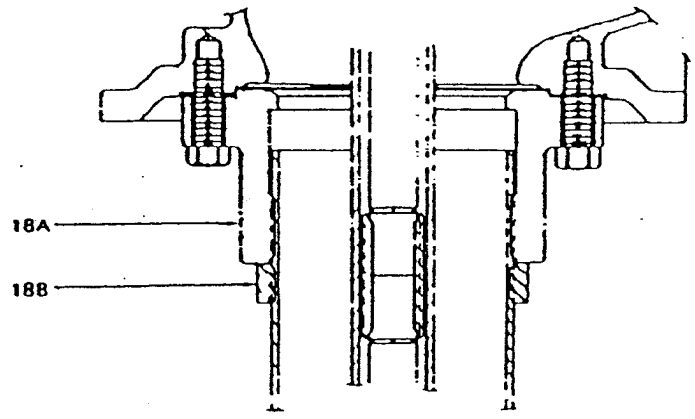
WATER LUBRICATED CONSTRUCTION



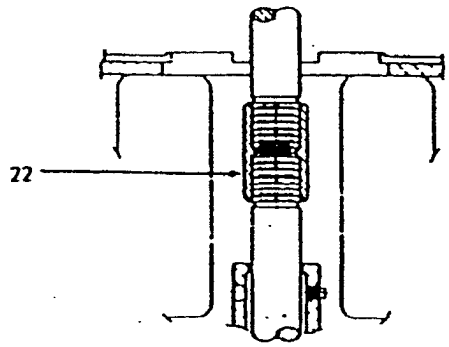
ADJUSTABLE TOP COLUMN ASSEMBLY

FIG. 7

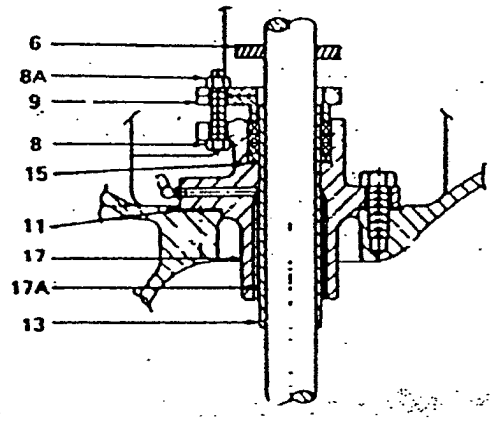




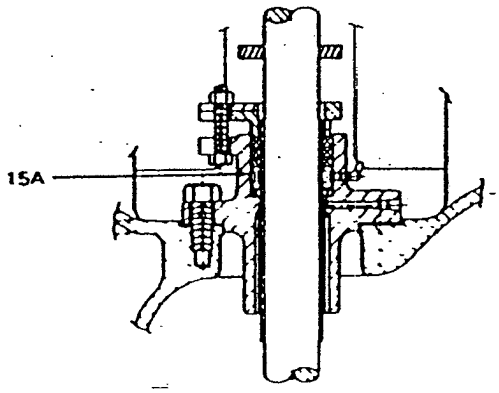
ADJUSTABLE TOP COLUMN ASSEMBLY



TWO PIECE TOP SHAFT



WATER LUBRICATED CONSTRUCTION



400 PSI PACKING BOX

FIG. 8

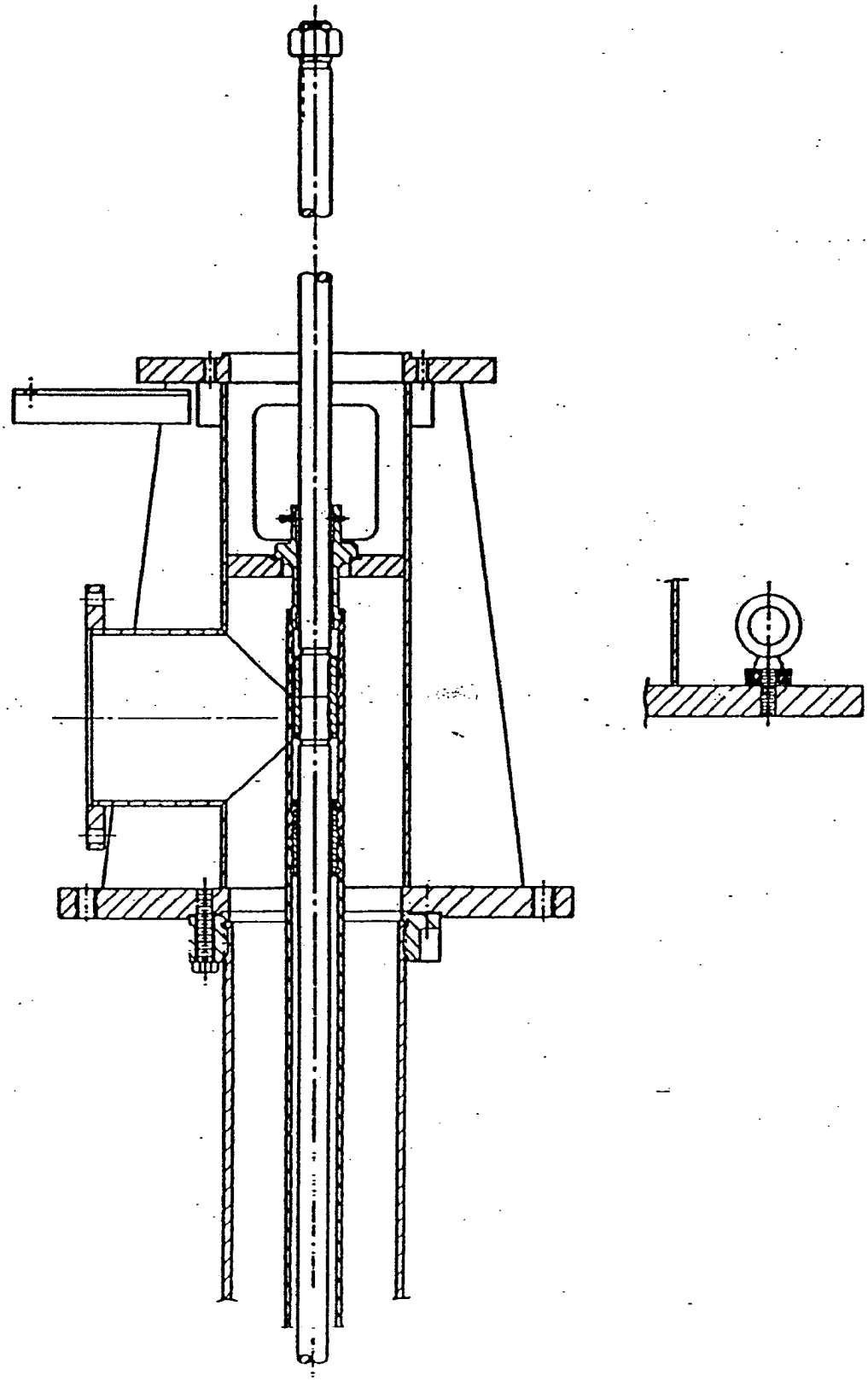
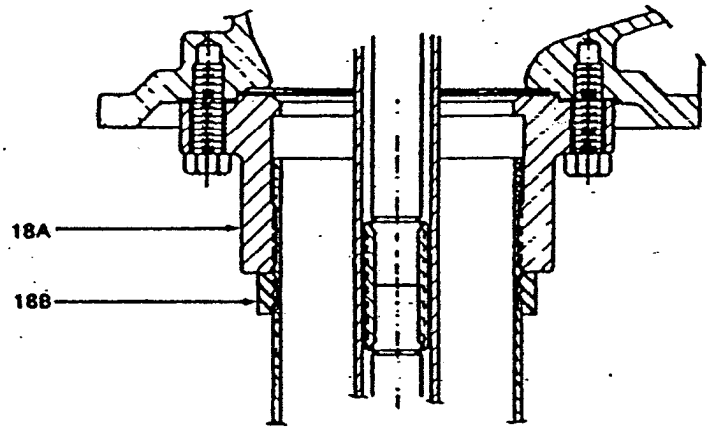
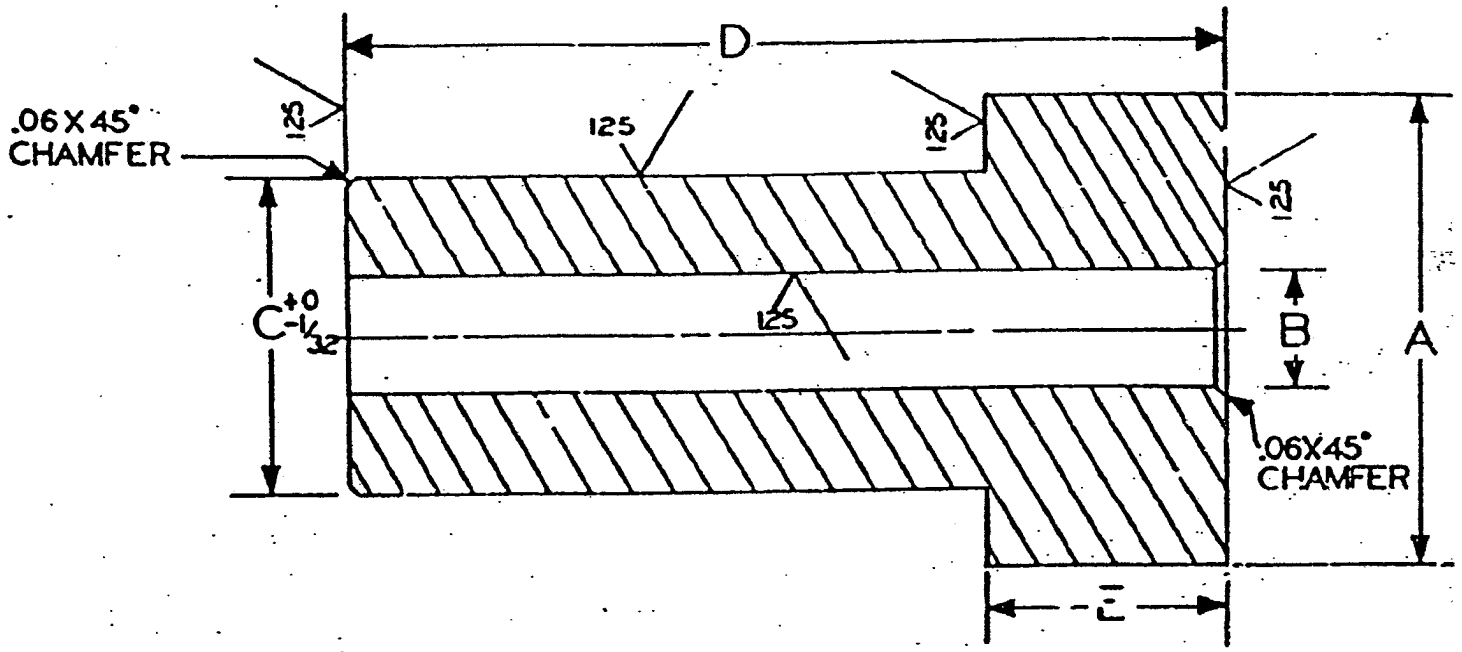


FIG. 15



ADJUSTABLE TOP COLUMN ASSEMBLY



PUMP SIZE	SHAFT DIA	BOLT SIZE	A	B	C	D	E
6M	1	$\frac{3}{8}$ x $1\frac{3}{4}$	$2\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{8}$	$1\frac{3}{16}$	$\frac{1}{2}$
7M	1	$\frac{3}{8}$ x 2	$2\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{8}$	$1\frac{7}{16}$	$\frac{1}{2}$
8M	$1\frac{3}{16}$	$\frac{3}{8}$ x 2	$2\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$
10M	$1\frac{7}{16}$	$\frac{3}{8}$ x $2\frac{1}{4}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{11}{16}$	$1\frac{3}{4}$	$\frac{1}{2}$
10XH	$1\frac{7}{16}$	$\frac{3}{8}$ x $3\frac{3}{4}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{7}{16}$	$3\frac{1}{4}$	$\frac{1}{2}$
11M 11H	$1\frac{7}{16}$	$\frac{3}{8}$ x $2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{11}{16}$	$1\frac{15}{16}$	$\frac{1}{2}$
12HC	$1\frac{11}{16}$	$\frac{3}{8}$ x $2\frac{7}{8}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{11}{16}$	$2\frac{3}{8}$	$\frac{1}{2}$
12MC	$1\frac{11}{16}$	$\frac{3}{8}$ x $5\frac{1}{2}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{5}{8}$	$4\frac{1}{2}$	$\frac{1}{2}$
12M 13H	$1\frac{11}{16}$	$\frac{3}{8}$ x $2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{11}{16}$	$2\frac{1}{8}$	$\frac{1}{2}$
12XH 14MC 14XH	$1\frac{15}{16}$	$\frac{3}{8}$ x $4\frac{1}{2}$	3	$\frac{7}{16}$	2	$4\frac{1}{8}$	$\frac{1}{2}$
14M 15H	$1\frac{15}{16}$	$\frac{3}{8}$ x $3\frac{1}{2}$	$2\frac{1}{2}$	$\frac{7}{16}$	$1\frac{11}{16}$	$2\frac{5}{16}$	$\frac{1}{2}$

FIG. 17

SHAFT LOCATING TOOL
T-7 TURBINE PUMPS
(FIG. 7000)

APPENDIX F

SEEPAGE PUMPBACK FLOW METER

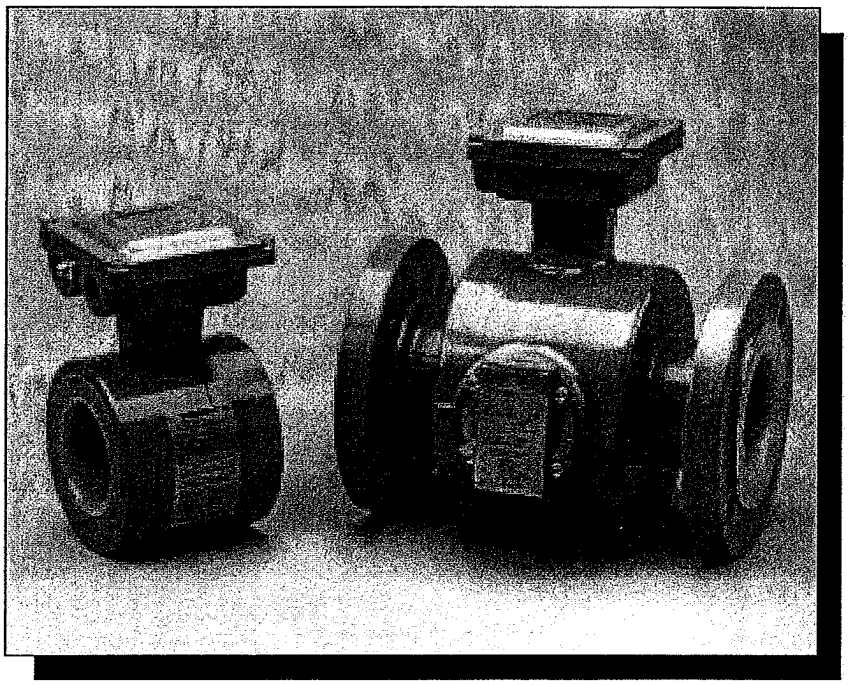
OPERATION MANUAL

Rosemont Inc. "Product Manual - Series 8700 Magnetic Flowmeter Flowtubes"

from http://www.emersonprocess.com/rosemeont/products/flowm8705.html

00809-0100-4727
English
Rev. DA

Series 8700 Magnetic Flowmeter Flowtubes



ROSEMOUNT®

FISHER-ROSEMOUNT™

Table of Contents

IMPORTANT

Procedures and instructions in this manual may require special precautions to ensure the safety of the personnel performing the operations. **Refer to the safety messages at the beginning of each section before performing any operations.**

Section 1 Introduction

MANUAL SCOPE

The Rosemount® Series 8700 Magnetic Flowmeter System combines separate flowtube and transmitter units. This manual is designed to assist in the installation and operation of Rosemount Model 8705, Model 8707 High-Signal, and Model 8711 Magnetic Flowmeter Flowtubes.

Specific transmitter information is located in the product manual for the Model 8712C/U/H (document 00809-0100-4729), Model 8732C (document 00809-0100-4725), or Model 8742C (document 00809-0100-4793) Magnetic Flowmeter Transmitters.

⚠WARNING

Attempting to install and operate Model 8705, Model 8707 High-Signal, or Model 8711 Magnetic Flowmeter Flowtubes without reviewing the instructions contained in this manual could result in personal injury or equipment damage.

Section 2: Installation

- installation instructions

Section 3: Start-Up and Operation

- flowtube calibration number
- flowtube configuration information.

Section 4: Troubleshooting

- troubleshooting procedures
- electrical circuit diagrams

Section 5: Model 8705 and Model 8707 High-Signal Flowtube Specifications

- specifications for Model 8705 and Model 8707
- reference tables
- dimensional drawings

Section 6: Model 8711 Flowtube Specifications

- specifications for Model 8711
- reference tables
- dimensional drawings

Appendix A: Field-Removable Electrodes

- instructions for removing and replacing the field-removable electrode assembly

Section 2 Installation

SAFETY MESSAGES

This section covers the steps required to physically install the flowtube. Instructions and procedures in this section may require special precautions to ensure the safety of the personnel performing the operations. Please refer to the following safety messages before performing any operation in this section.

⚠WARNING

Failure to follow these installation guidelines could result in death or serious injury:

Installation and servicing instructions are for use by qualified personnel only. Performing any servicing other than that contained in this manual may result in death or serious injury. Do not perform any servicing other than that contained in the operating instructions, unless qualified.

⚠CAUTION

The flowtube liner is vulnerable to handling damage. Never place anything through the flowtube for the purpose of lifting or gaining leverage. Liner damage can render the flowtube useless.

⚠CAUTION

To avoid possible damage to the flowtube liner ends, do not use metallic or spiral-wound gaskets. If frequent removal is anticipated, take precautions to protect the liner ends. Short spool pieces attached to the flowtube ends are often used for protection.

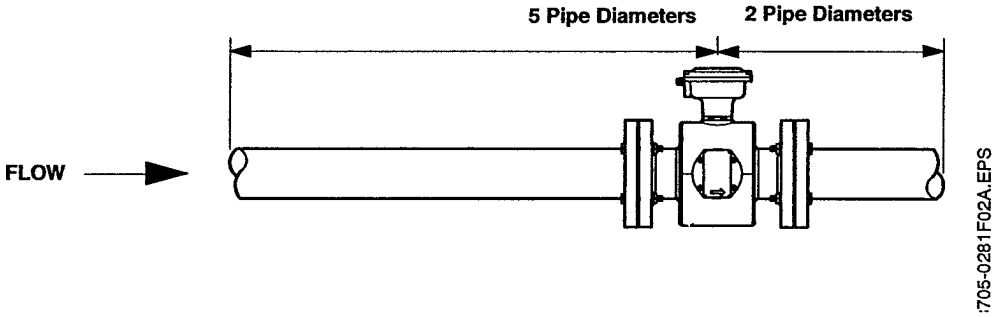
⚠CAUTION

Correct flange bolt tightening is crucial for proper flowtube operation and life. All bolts must be tightened in the proper sequence to the specified torque limits. Failure to observe these instructions could result in severe damage to the flowtube lining and possible flowtube replacement.

Upstream/ Downstream Piping

To ensure specification accuracy over widely varying process conditions, install the flowtube a minimum of five straight pipe diameters upstream and two pipe diameters downstream from the electrode plane (see Figure 2-2).

FIGURE 2-2. Upstream and Downstream Straight Pipe Diameters



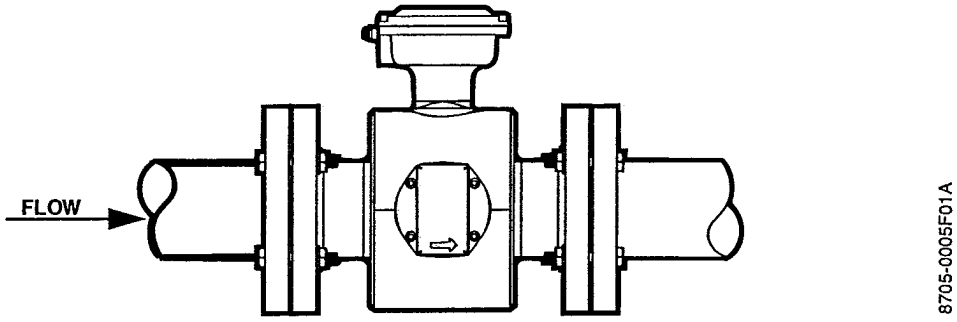
Flowtube Orientation

The flowtube should be installed in a position that ensures the flowtube remains full during operation. Horizontal or inclined positions are preferred. Figures 2-3, 2-4, and 2-5 show the proper flowtube orientation for the most common installations.

The following orientations ensure that the electrodes are in the optimum plane to minimize the effects of entrapped gas. Further information on electrode orientation can be found in Appendix A.

As illustrated in Figures 2-4B and 2-5B, avoid *downward* flows where back pressure does not ensure that the flowtube remains full at all times.

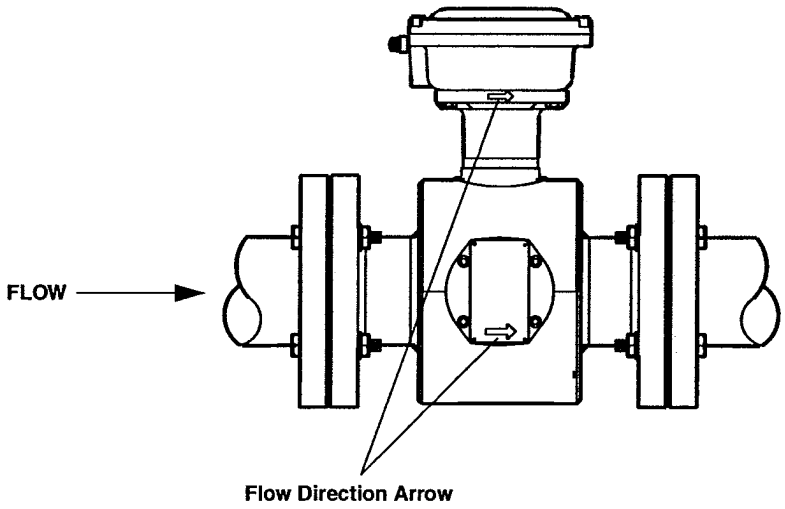
FIGURE 2-3. Horizontal Flowtube Orientation



Flow Direction

The flowtube should be mounted so that the FORWARD end of the flow arrow, shown on the flowtube identification tag, points in the direction of flow through the tube (see Figure 2-6). In this mounting configuration, the conduit ports point upstream.

FIGURE 2-6. Flow Direction



STEP 3: INSTALLATION OF MODEL 8705 AND MODEL 8707 HIGH-SIGNAL

The following drawings should be used as a guide in the installation of the Model 8705 and Model 8707 High-Signal Flowtubes. Refer to page 2-8 for installation of the Model 8711 Flowtube.

Gaskets

⚠ The flowtube requires a gasket at each of its connections to adjacent devices or piping. The gasket material selected must be compatible with the process fluid and operating conditions. Metallic or spiral-wound gaskets can damage the liner. If the gaskets will be removed frequently, protect the liner ends.

A gasket is required on each side of the grounding ring, as shown in Figure 2-7. All other applications (including lining protector and grounding electrode) require only one gasket on each end connection, as shown in Figure 2-8.

⚠ See **Safety Messages** on page 2-1 for complete warning information.

FIGURE 2-9. Flange Bolt Torquing Sequence

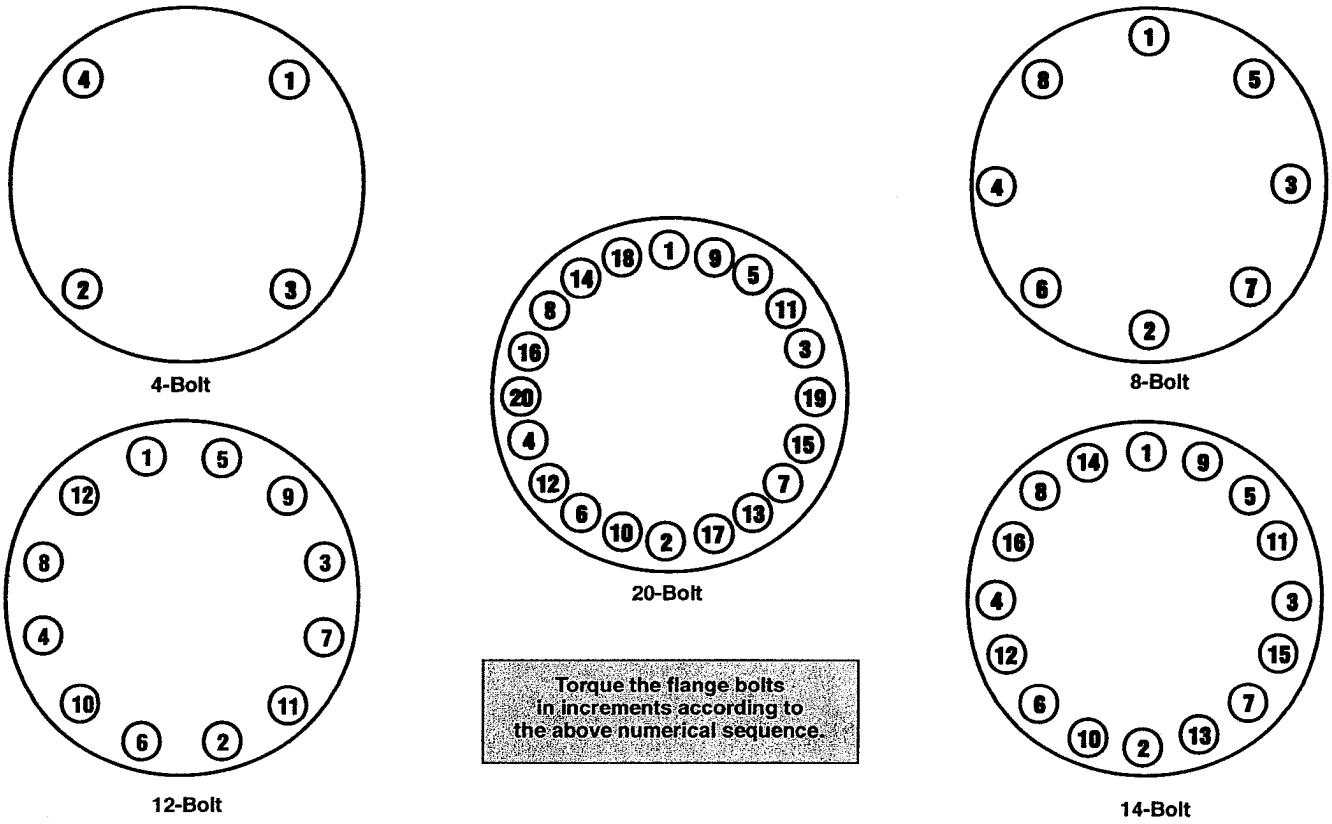
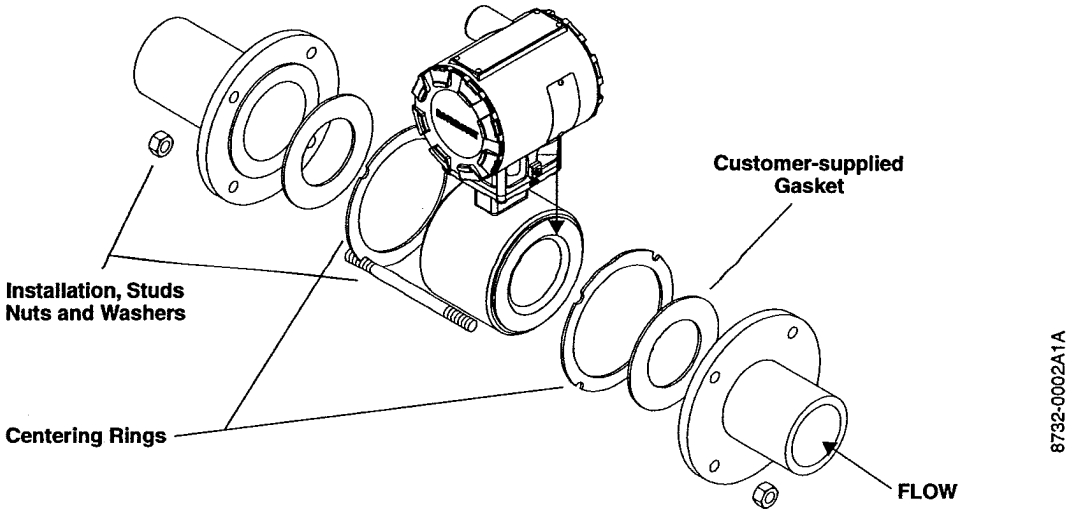


TABLE 2-1. Flange Bolt Torque Specifications for Model 8705 and Model 8707 High-Signal Flowtubes

Size Code	Line Size	Class 150 (pound-feet)	Class 300 (pound-feet)
005	½-inch (15 mm)	10	10
010	1 inch (25 mm)	10	10
015	1½ inch (40 mm)	17	22
020	2 inch (50 mm)	25	17
030	3 inch (80 mm)	45	35
040	4 inch (100 mm)	35	50
060	6 inch (150 mm)	60	65
080	8 inch (200 mm)	80	60
100	10 inch (250 mm)	70	65
120	12 inch (300 mm)	80	80
140	14 inch (350 mm)	100	–
160	16 inch (400 mm)	90	–
180	18 inch (450 mm)	125	–
200	20 inch (500 mm)	125	–
240	24 inch (600 mm)	150	–
300	30 inch (750 mm)	150	–
360	36 inch (900 mm)	200	–

FIGURE 2-10. Gasket Placement with Centering Rings



Flange Bolts

Flowtube sizes and torque values for both Class 150 and Class 300 flanges are listed in Table 2-3. Tighten flange bolts in the incremental sequence, shown in Figure 2-9.

Always check for leaks at the flanges after tightening the flange bolts. All flowtubes require a second torquing 24 hours after initial flange bolt tightening.

TABLE 2-3. Torque specifications

Size Code	Line Size	Pound-feet	Newton-meter
15F	0.15 inch (4 mm)	5	6.8
30F	0.30 inch (8 mm)	5	6.8
005	½-inch (15 mm)	5	6.8
010	1 inch (25 mm)	10	13.6
015	1½ inch (40 mm)	15	20.5
020	2 inch (50 mm)	25	34.1
030	3 inch (80 mm)	40	54.6
040	4 inch (100 mm)	30	40.1
060	6 inch (150 mm)	50	68.2
080	8 inch (200 mm)	70	81.9

FIGURE 2-11. No Grounding Options or Grounding Electrode in Lined Pipe

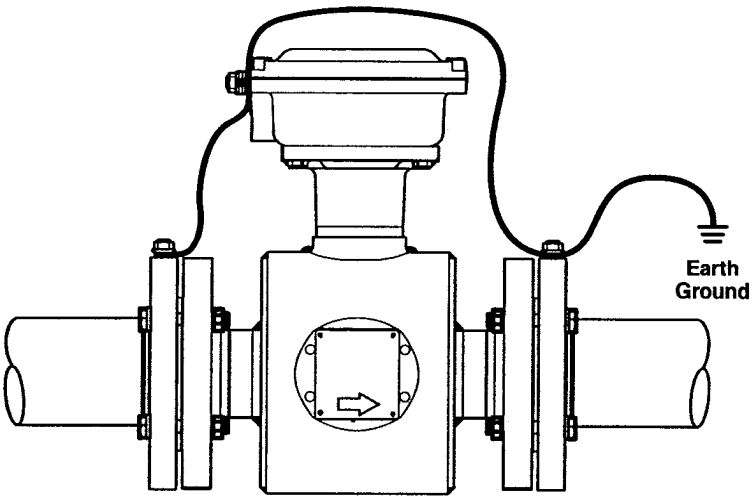
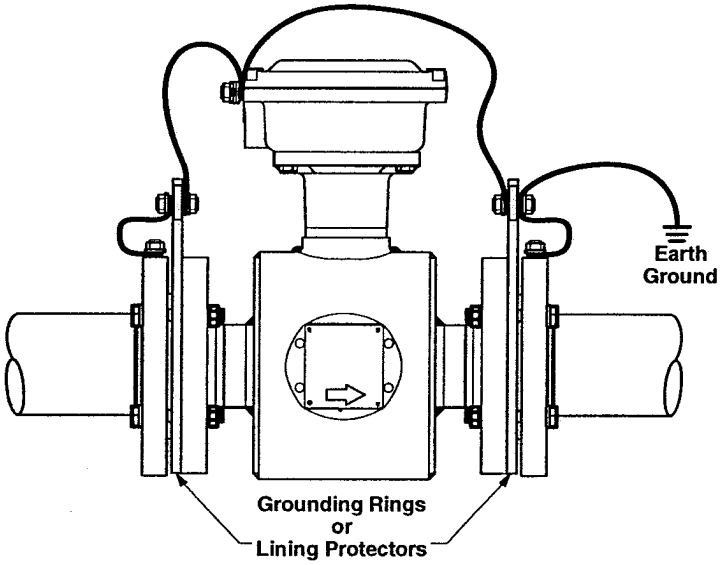


FIGURE 2-12. Grounding with Grounding Rings or Lining Protectors



STEP 5: WIRING

The conduit connections needed for installation depend on transmitter location. A conduit run between the flowtube and transmitter is not required if the transmitter is integrally mounted on the flowtube.

Conduit Ports and Connections

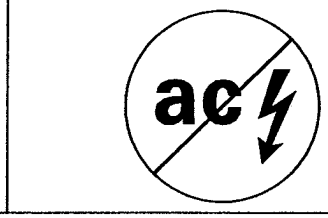
Both the flowtube and transmitter junction boxes have ports for ¾-inch NPT conduit connections. These connections should be made in accordance with local or plant electrical codes. Unused ports should be sealed with metal plugs. Housing damage will result if metal plugs are overtightened.

Flanged and wafer flowtubes have two conduit ports as shown in Figures 1, 2, 3, and 1. Either one may be used for both the coil drive and electrode cables. Use the stainless steel plug that is provided to seal the unused conduit port.

Series 8700 Flowtubes use a pulsed-dc signal generated by Model 8712C/U/H, Model 8732C, or Model 8742C Magnetic Flowmeter Transmitter. Connect the Model 8712H High-Signal Magnetic Flowmeter Transmitter only to the Model 8707 High-Signal Flowtube.

⚠CAUTION

This is a pulsed dc magnetic flowmeter. **Do not connect ac power to the flowtube or to terminals 1 and 2 of the transmitter,** or replacement of the electronics board will be necessary.



A single dedicated conduit run for the coil drive and electrode cables is needed between a flowtube and a remote transmitter. Bundled cables in a single conduit are likely to create interference and noise problems in your system. Use one set of cables per conduit run. See Figure 2-15 for proper conduit installation diagram and Table 2-5 for recommended cable.

Use wire rated for the proper temperature application. For connections in ambient temperatures above 140 °F (60 °C), use a wire rated for 176 °F (80 °C). For ambients greater than 176 °F (80 °C), use a wire rated for 230 °F (110 °C).

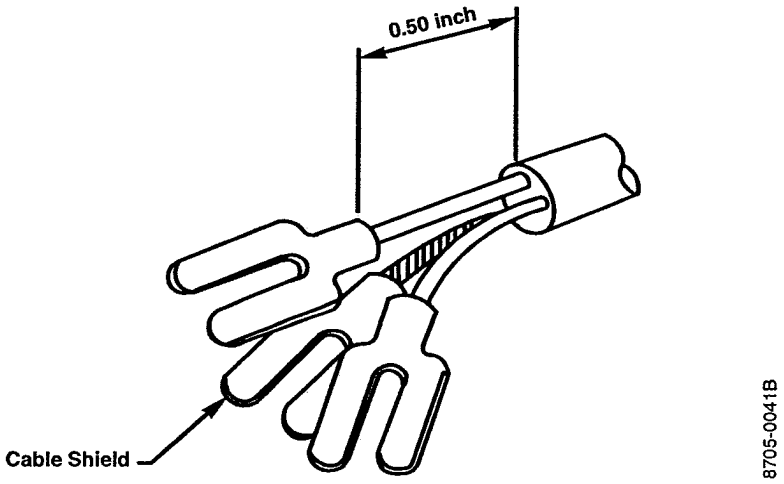
Cable Preparation

Prepare the flowtube ends of the coil drive and electrode cables, as shown in Figure 2-16.

NOTE
The maximum length for unshielded wire in the wiring compartment is ½-inch.

Correct cable preparation is important for a successful installation. The cable shield should be stripped back no more than 0.50 inch. If more wire is exposed, electrical noise will increase and create unstable meter readings.

FIGURE 2-16. Cable Preparation Detail



IMPORTANT
Failure to connect the cable shields will result in improper operation. Series 8700 Flowtube Systems require that the cable shields be connected at the flowtube for proper operation.

High-Signal Flowtube to High-Signal Transmitter Connections

Connect coil drive and electrode cables as shown in Figure 2-18.

FIGURE 2-18. Wiring Diagram to Model 8712H High-Signal Transmitter

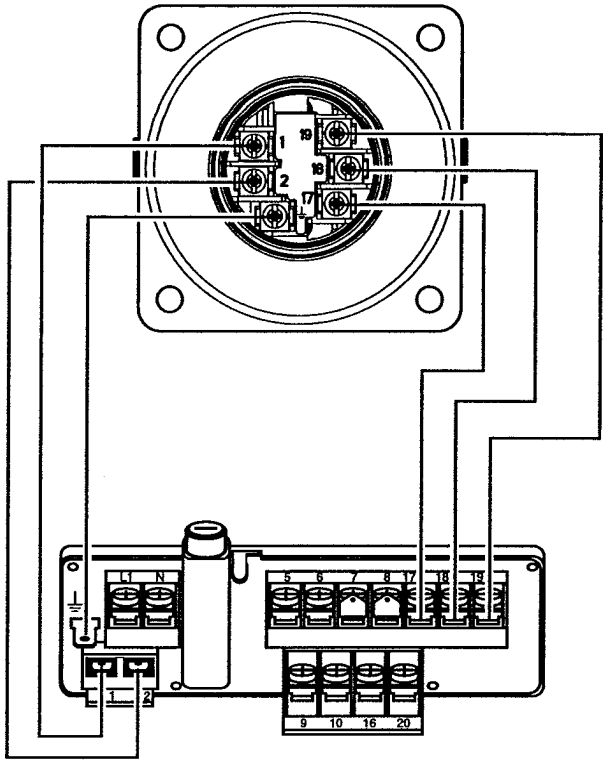


TABLE 2-7. High-Signal Flowtube to High-Signal Transmitter

Rosemount Model 8712H Transmitters	Rosemount Model 8707 Flowtubes
1	1
2	2
⏚	⏚
17	17
18	18
19	19

⚠CAUTION

This is a pulsed dc magnetic flowmeter. **Do not connect ac power to the flowtube or to terminals 1 and 2 of the transmitter,** or replacement of the electronics board will be necessary.

STEP 6: PROCESS LEAK PROTECTION (MODEL 8705 AND MODEL 8707 HIGH-SIGNAL ONLY)

The Model 8705 and Model 8707 High-Signal Flowtube housing is fabricated from carbon steel to perform two separate functions. First, it provides shielding for the flowtube magnetics so that external disturbances cannot interfere with the magnetic field and thus affect the flow measurement. Second, it provides the physical protection to the coils and other internal components from contamination and physical damage that might occur in an industrial environment. The housing is completely welded and gasket-free.

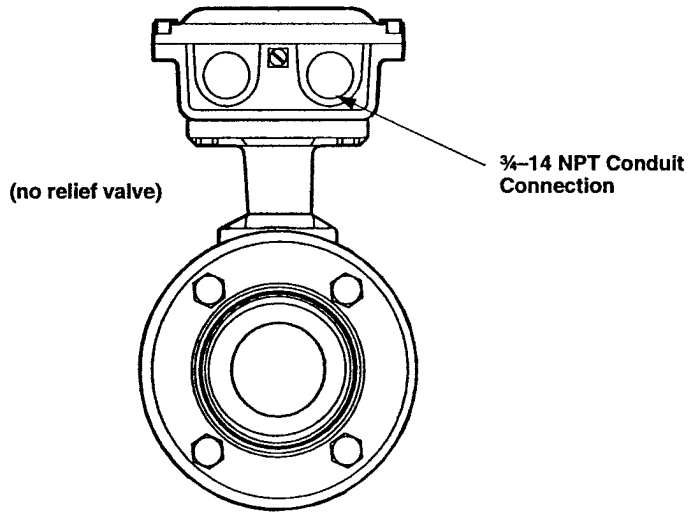
The three housing configurations are identified by the W0, W1, or W3 in the model number option code when ordering. Below are brief descriptions of each housing configuration, which are followed by a more detailed overview.

- **Code W0** — sealed, welded coil housing (standard configuration)
- **Code W1** — sealed, welded coil housing with a relief valve capable of venting fugitive emissions to a safe location (additional plumbing from the flowtube to a safe area, installed by the user, is required to vent properly)
- **Code W3** — sealed, welded coil housing with separate electrode compartments capable of venting fugitive emissions (additional plumbing from the flowtube to a safe area, installed by the user, is required to vent properly)

Standard Housing Configuration

The standard housing configuration is identified by a code W0 in the model number. This configuration does not provide separate electrode compartments with external electrode access. In the event of a process leak, these models will not protect the coils or other sensitive areas around the flowtube from exposure to the pressure fluid.

FIGURE 2-20. Standard Housing — Configuration Sealed Welded Housing (Option Code W0)



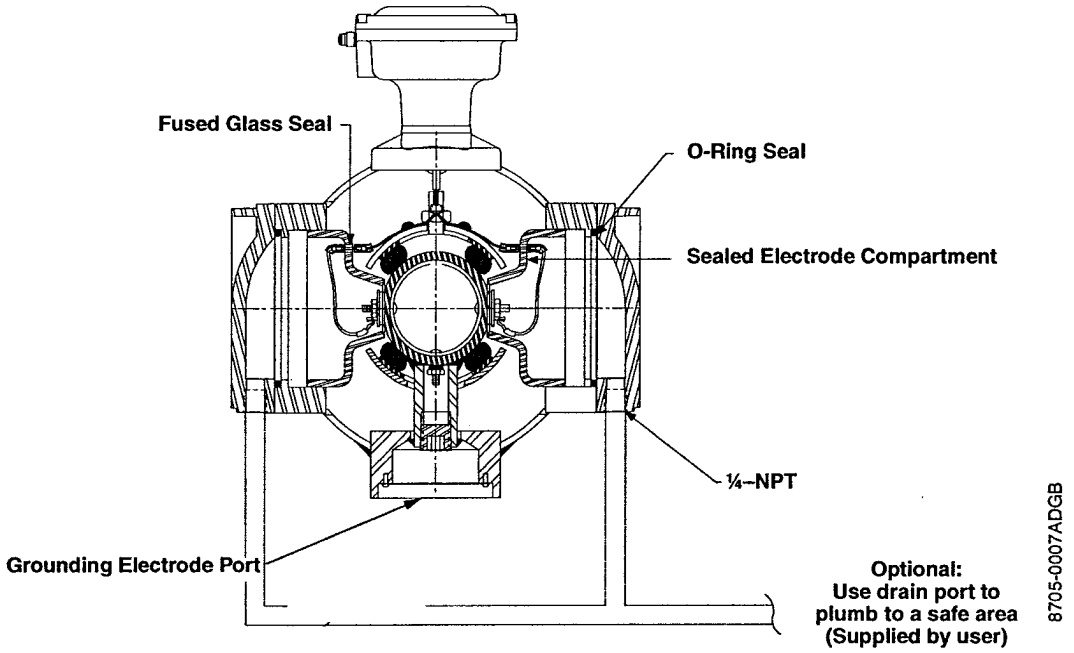
Process Leak Containment

The second optional configuration, identified as option code W3 in the model number, divides the coil housing into three compartments: one for each electrode and one for the coils. Should a damaged liner or electrode fault process fluid to migrate behind the electrode seals, the fluid is contained in the electrode compartment. The sealed electrode compartment prevents the process fluid from entering the coil compartment where it would damage the coils and other internal components.

The electrode compartments are designed to contain the process fluid at full line pressure. An o-ring sealed cover provides access to each of the electrode compartments from outside the flowtube; drainports are provided in each cover for the removal of fluid.

NOTE
The electrode compartment could contain full line pressure and it must be depressurized before the cover is removed.

FIGURE 2-22. Housing Configuration — Sealed Electrode Compartment (Option Code W3)



If necessary, capture any process fluid leakage, connect the appropriate piping to the drainports, and provide for proper disposal (see Figure 2-22).

Section 3

Troubleshooting

SAFETY MESSAGES

Instructions and procedures in this section may require special precautions to ensure the safety of the personnel performing the operations. Refer to the following safety messages before performing any operation in this section.

⚠WARNING

Failure to follow these installation guidelines could result in death or serious injury:

Installation and servicing instructions are for use by qualified personnel only. Performing any servicing other than that contained in this manual may result in death or serious injury. Do not perform any servicing other than that contained in the operating instructions, unless qualified.

⚠WARNING

Mishandling products exposed to a hazardous substance may result in death or serious injury. If the product being returned was exposed to a hazardous substance as defined by OSHA, a copy of the required Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned goods.

INDEPENDENT FLOWTUBE AND TRANSMITTER REPLACEMENT

Rosemount flow lab tests determine individual flowtube characteristics and account for them with the 16-digit calibration number. Flowtube interchangability reduces the need for spare transmitters. It also ensures factory-calibrated accuracy without additional calibration procedures or equipment. The unique calibration number is loaded into the transmitters, enabling the interface of a Rosemount flowtube to communicate with a Rosemount transmitter. A description of the flowtube calibration number is included on page 2-22.

TABLE 3-1. Flowtube Troubleshooting

Step 1		Step 2		Step 3
Test A–Flowtube Coil				
Disconnect power from the transmitter by removing the fuse. Disconnect wires 1 and 2 from the transmitter.	➤	Measure the resistance across wires 1 and 2 going to the flowtube, using the lowest ohms scale. The reading should be between 2 and 18 Ω.	➤	A reading outside this range indicates that the coils or cables may be open or shorted.
Test B– Coil Shield to Coil				
Disconnect power from the transmitter by removing the fuse. Disconnect wires 1, 2, and ground from the transmitter.	➤	Measure the resistance from the coil shield (ground) to wires 1 and 2 using the highest scale. Both readings should be overrange.	➤	Any reading on the scale indicates that the coils are shorted to the housing.
Test C– Electrode Shield to Electrode (See Note Below)				
Disconnect power from the transmitter by removing the fuse. Disconnect wires 17, 18, and 19 from the transmitter. Test with process in the flowtube (either flow or no flow).	➤	Measure the resistance from wire 17 to 18 and 17 to 19. This reading will change as you hold the leads on the wires, so use the initial reading. These readings should both be between 1 kΩ and 3 MΩ and close to each other.	➤	A reading near 68kΩ or 0Ω indicates a possible shorted electrode. A stable reading indicates a shorted electrode. A high reading indicates a possible coated electrode, non-conductive process, or electrode not in contact with process.
Test D– Positive to Negative Electrode (See Note Below)				
Disconnect power from the transmitter by removing the fuse. Disconnect wires 18, and 19 from the transmitter. Test with process in the flowtube (either flow or no flow).	➤	Measure the resistance between wires 18 and 19. This reading should be in the range between 100 kΩ and 2MΩ.	➤	An overrange reading indicates a coated electrode, non-conductive process, or electrode not in contact with the process.
Test E– Coils to Electrode				
Disconnect power from the transmitter by removing the fuse. Disconnect all wires from the transmitter.	➤	Measure the resistance between wires 1 or 2 and 18 and between 1 or 2 and 19. Both readings should be in overrange.	➤	Any reading on scale indicates a resistive path from the coils to electrode.

Section 4

Specifications: Model 8705 and Model 8707 High-Signal Flowtubes

SPECIFICATIONS

Functional Specifications

Service
Conductive liquids and slurries

Line Sizes
½–36 inch (15–900 mm) for Model 8705
3–36 inch (80–600 mm) for Model 8707

Interchangeability
Model 8705 flowtubes are interchangeable with Model 8712C/U, Model 8732, and Model 8742C Transmitters. Model 8707 High-Signal Flowtubes are interchangeable with Model 8712H High-Signal Transmitters. System accuracy is maintained regardless of line size or optional features. Each flowtube nameplate has a sixteen-digit calibration number that can be entered into a transmitter through the Local Operator Interface (LOI) or the HART Communicator on the Model 8712C/U/H and the Model 8732C. In a FOUNDATION™ fieldbus environment, the Model 8742C can be configured using the DeltaV™ fieldbus configuration tool or another FOUNDATION fieldbus configuration device. No further calibration is necessary.

Upper Range Limit

30 ft/s (10 m/s)

Process Temperature Limits

Teflon (PTFE) Lining

–20 to 350 °F (–29 to 177 °C)

Tefzel (ETFE) Lining

–20 to 300 °F (–29 to 149 °C)

Polyurethane Lining

0 to 140 °F (–18 to 60 °C)

Neoprene Lining

0 to 185 °F (–18 to 85 °C)

Linatex Lining (Not available for Model 8707)

0 to 158 °F (–18 to 70°C)

Ambient Temperature Limits
–30 to 150 °F (–34 to 65 °C)

Ambient Conditions
Overvoltage category I. Pollution Degree 2

N5 Factory Mutual (FM) Approval Dust-ignition proof for Class II/III, Division 1 Groups E, F, and G; Non-incendive for Class I, Division 2 Groups A, B, C, and D; T5 temperature code; For flammable process fluid service

KD KEMA/CENELEC (Model 8705 only)
EEx e ia IIC T3...T6 (See Table 3)
AND
CE Marking (Model 8705 only)

TABLE 4-3. Relation Between Ambient Temperature, Process Temperature, and Temperature Class[1]

Meter Size (inches)	Maximum Ambient Temperature	Maximum Process Temperature	Temperature Class
1/2	149 °F (65 °C)	240 °F (116 °C)	T3
1	149 °F (65 °C)	248 °F (120 °C)	T3
1	95 °F (35 °C)	95 °F (35 °C)	T4
1 1/2	149 °F (65 °C)	257 °F (125 °C)	T3
1 1/2	140 °F (60 °C)	140 °F (60 °C)	T4
2	149 °F (65 °C)	257 °F (125 °C)	T3
2	149 °F (65 °C)	167 °F (75 °C)	T4
2	104 °F (40 °C)	104 °F (40 °C)	T5
3 - 4	149 °F (65 °C)	266 °F (130 °C)	T3
3 - 4	149 °F (65 °C)	167 °F (75 °C)	T4
3 - 4	131 °F (55 °C)	194 °F (90 °C)	T5
3 - 4	104 °F (40 °C)	104 °F (40 °C)	T6
6	149 °F (65 °C)	175 °F (79 °C)	T3
6	149 °F (65 °C)	167 °F (75 °C)	T4
6	149 °F (65 °C)	230 °F (110 °C)	T5
6	140 °F (60 °C)	140 °F (60 °C)	T6
8 - 36	149 °F (65 °C)	284 °F (140 °C)	T3
8 - 36	149 °F (65 °C)	240 °F (116 °C)	T4
8 - 36	149 °F (65 °C)	176 °F (80 °C)	T5
8 - 36	149 °F (65 °C)	149 °F (65 °C)	T6

(1) This table is applicable for KEMA/CENELEC approval only.

Conductivity Limits

Process liquid must have a conductivity of 5 microsiemens/cm (5 micromhos/cm) or greater for Model 8705. Process liquid must have a conductivity of 50 microsiemens/cm (50 micromhos/cm) for Model 8707 (excludes the effect of interconnecting cable length in remote mount transmitter installations).

Performance Specifications

(System specifications are given using the frequency output and with the unit at referenced conditions.)

Accuracy

Model 8705 with Model 8712C/U, Model 8732C, or Model 8742C

±0.5% of rate from 1 to 30 ft/s (0.3 to 10 m/s); includes combined effects of linearity, hysteresis, repeatability, and calibration uncertainty; accuracy is ±0.005 ft/s (±0.0015 m/s) from low-flow cutoff to 1.0 ft/s (0.3 m/s)

Model 8707 with Model 8712C/U/H, Model 8732C, or Model 8742C

±0.5% of rate from 3 to 30 ft/s (1 to 10 m/s); include combined effects of linearity, hysteresis, repeatability and calibration uncertainty; accuracy is ±0.015 ft/s (±0.0045 m/s) from low-flow cutoff to 3.0 ft/s (1 m/s)

Lining Protectors

Lining protectors are installed between the flange and the tube face on both ends of the flowtube. The leading edge of lining material is protected by the lining protector; lining protectors cannot be removed once they are installed. Lining protectors are available in 316L SST, Hastelloy-C, and titanium.

Flowtube Dimensions

See Table 5, Table 7, Table 6

See Figure ?-??, Figure ?-??, and Figure ?-??

Weight

See Table 4

TABLE 4-4. Flowtube Weight

CF = Consult Factory

Nominal Line Size[1] Inches (mm)	Flowtube Flange Rating		Flowtube Weight lb (kg)
	ASME B16.5 (ANSI)	DIN	
½ (15)	150	PN 40	20 (9)
½ (15)	300		22 (10)
1 (25)	150	PN 40	20 (9)
1 (25)	300		22 (10)
1½ (40)	150	PN 40	22 (10)
1½ (40)	300		24 (11)
2 (50)	150	PN 40	26 (12)
2 (50)	300		28 (13)
3 (80)	150	PN 40	40 (18)
3 (80)	300		47 (21)
4 (100)	150	PN 16	48 (22)
4 (100)	300		65 (30)
6 (150)	150	PN 16	81 (37)
6 (150)	300		93 (42)
8 (200)	150	PN 10	110 (50)
8 (200)	300		162 (74)
10 (250)	150	PN 10	220 (98)
10 (250)	300		300 (136)
12 (300)	150	PN 10	330 (150)
12 (300)	300		435 (197)
14 (350)	150	PN 10	370 (168)
16 (400)	150	PN 10	500 (227)
18 (450)	150	PN 10	600 (272)
20 (500)	150	PN 10	680 (308)
24 (600)	150	PN 10	1,000 (454)
30 (750)	125	CF	1,400 (637)
36 (900)	125	CF	1,975 (898)

(1) 30- and 36-inch AWWA C207 Table 2 Class D rated to 150 psi at 150 °F (66 °C).

TABLE 4-7. Model 8705 Flowtube Dimensions with DIN Flanges in Millimeters (Inches)

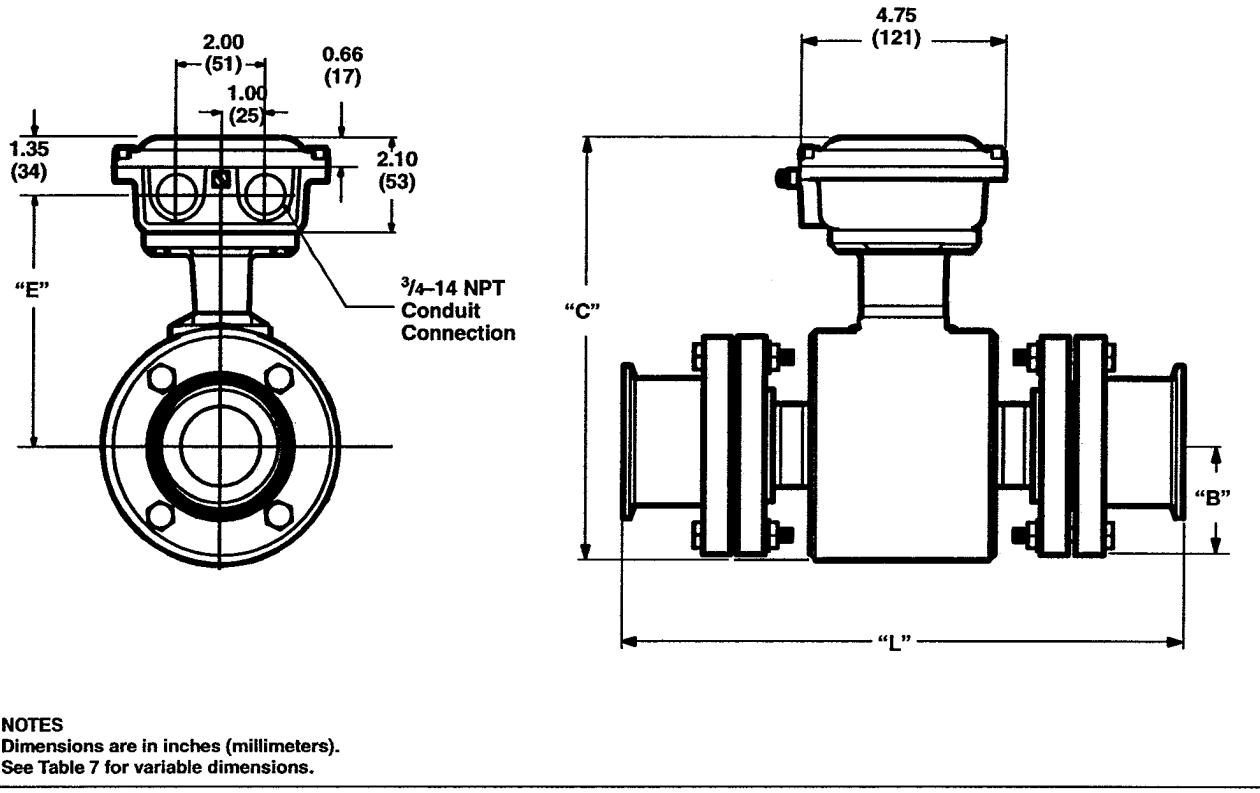
Line Size[1] and Flange Rating	Liner Face Diameter "A"	Process Flange Rad. "B"	Overall Flowtube Length "L"[2]	Body Height "C"	Body Width "D" with Port	Centerline to Conduit "E"	Bolt Hole Circle Diameter	Bolt Hole Diameter	Number of Bolts
15 mm PN 10–40	45 (1.77)	47 (1.87)	200 (7.88)	222 (8.75)	175 (6.88)	131 (5.16)	65 (2.56)	14 (0.55)	4
25 mm PN 10–40	68 (2.68)	58 (2.27)	200 (7.88)	222 (8.75)	186 (7.34)	131 (5.16)	85 (3.35)	14 (0.55)	4
40 mm PN 10–40	88 (3.46)	75 (2.96)	200 (7.87)	242 (9.52)	179 (7.05)	141 (5.57)	110 (4.33)	18 (0.71)	4
50 mm PN 10–40	102 (4.02)	83 (3.25)	200 (7.87)	242 (9.52)	190 (7.47)	141 (5.57)	125 (4.92)	18 (0.71)	4
80 mm PN 10–40	138 (5.43)	100 (3.94)	200 (7.87)	293 (11.52)	243 (9.57)	167 (6.57)	160 (6.30)	18 (0.71)	8
100 mm PN 10–16	158 (6.22)	110 (4.33)	250 (9.84)	310 (12.22)	254 (10.01)	176 (6.92)	180 (7.09)	18 (0.71)	8
100 mm PN 25–40	162 (6.38)	117 (4.63)	250 (9.84)	310 (12.22)	254 (10.01)	176 (6.92)	190 (7.48)	22 (0.87)	8
150 mm PN 10–16	212 (8.35)	142 (5.61)	300 (11.81)	366 (14.39)	264 (10.41)	204 (8.05)	240 (9.45)	22 (0.87)	8
150 mm PN 25	218 (8.58)	150 (5.91)	300 (11.81)	366 (14.39)	264 (10.41)	204 (8.05)	240 (9.45)	22 (0.87)	8
150 mm PN 40	218 (8.58)	150 (5.91)	332 (13.06)	366 (14.39)	264 (10.41)	204 (8.05)	240 (9.45)	22 (0.87)	8
200 mm PN 10	268 (10.55)	170 (6.70)	351 (13.81)	415 (16.33)	289 (13.38)	229 (9.02)	295 (11.61)	22 (0.87)	8
200 mm PN 16	268 (10.55)	170 (6.70)	351 (13.81)	415 (16.33)	289 (13.38)	229 (9.02)	295 (11.61)	22 (0.87)	8
200 mm PN 25	278 (10.94)	180 (7.09)	350 (13.78)	415 (16.33)	289 (13.38)	229 (9.02)	310 (12.20)	26 (1.02)	12
200 mm PN 40	285 (11.22)	187 (7.38)	396 (15.60)	415 (16.33)	289 (13.38)	229 (9.02)	320 (12.60)	30 (1.18)	12
250 mm PN 10	320 (12.60)	197 (7.70)	381 (15.00)	485 (19.11)	432 (17.00)	265 (10.44)	350 (13.78)	22 (0.87)	12
250 mm PN 16	320 (12.60)	202 (7.97)	381 (15.00)	485 (19.11)	432 (17.00)	265 (10.44)	355 (13.98)	26 (1.02)	12
250 mm PN 25	335 (13.19)	213 (8.39)	381 (15.00)	485 (19.11)	432 (17.00)	265 (10.44)	370 (14.67)	30 (1.18)	12
250 mm PN 40	345 (13.58)	225 (8.86)	435 (17.13)	485 (19.11)	432 (17.00)	265 (10.44)	385 (15.16)	33 (1.30)	12
300 mm PN 10	370 (14.57)	223 (8.76)	457 (18.00)	540 (21.27)	487 (19.16)	265 (10.44)	400 (15.75)	22 (0.87)	12
300 mm PN 16	378 (14.88)	230 (9.06)	457 (18.00)	540 (21.27)	487 (19.16)	293 (11.52)	410 (16.14)	26 (1.02)	12
300 mm PN 25	395 (15.55)	242 (9.55)	457 (18.00)	540 (21.27)	487 (19.16)	293 (11.52)	430 (16.93)	30 (1.18)	16
300 mm PN 40	410 (16.14)	258 (10.12)	512 (20.14)	540 (21.27)	487 (19.16)	293 (11.52)	450 (17.72)	33 (1.30)	16
350 mm PN 10	430 (16.93)	252 (9.94)	534 (21.03)	594 (23.39)	541 (21.28)	293 (11.52)	460 (18.11)	22 (0.87)	16
350 mm PN 16	438 (17.24)	260 (10.24)	534 (21.03)	594 (23.39)	541 (21.28)	320 (12.58)	470 (18.50)	26 (1.02)	16
350 mm PN 25	450 (17.72)	277 (10.93)	534 (21.03)	594 (23.39)	541 (21.28)	320 (12.58)	490 (19.29)	33 (1.30)	16
350 mm PN 40	465 (18.31)	290 (11.42)	591 (23.25)	594 (23.39)	541 (21.28)	320 (12.58)	510 (20.08)	36 (1.42)	16
400 mm PN 10	482 (18.98)	282 (11.12)	610 (24.00)	645 (25.04)	592 (23.30)	345 (13.59)	515 (20.28)	26 (1.02)	16
400 mm PN 16	490 (19.29)	290 (11.42)	610 (24.00)	645 (25.04)	592 (23.30)	345 (13.59)	525 (20.67)	30 (1.18)	16
400 mm PN 25	505 (19.88)	310 (12.21)	610 (24.00)	645 (25.04)	592 (23.30)	345 (13.59)	550 (21.65)	36 (1.42)	16
400 mm PN 40	535 (21.06)	330 (12.99)	667 (26.25)	645 (25.04)	592 (23.30)	345 (13.59)	585 (23.03)	39 (1.54)	16
450 mm PN 10	532 (20.94)	308 (12.13)	686 (27.00)	709 (27.93)	656 (25.82)	377 (14.85)	565 (22.24)	26 (1.02)	20
450 mm PN 16	550 (21.65)	320 (12.60)	686 (27.00)	709 (27.93)	656 (25.82)	377 (14.85)	585 (23.03)	30 (1.18)	20
450 mm PN 40	560 (22.05)	343 (13.50)	765 (30.12)	709 (27.93)	656 (25.82)	377 (14.85)	610 (24.02)	30 (1.18)	20
500 mm PN 10	585 (23.03)	335 (13.19)	762 (30.00)	761 (29.95)	707 (27.84)	403 (15.86)	620 (24.41)	26 (1.02)	20
500 mm PN 16	610 (24.02)	358 (14.08)	762 (30.00)	761 (29.95)	707 (27.84)	403 (15.86)	650 (25.59)	33 (1.30)	20
500 mm PN 25	615 (24.21)	365 (14.37)	762 (30.00)	761 (29.95)	707 (27.84)	403 (15.86)	660 (25.98)	36 (1.42)	20
500 mm PN 40	615 (24.21)	378 (14.88)	845 (33.25)	761 (29.95)	707 (27.84)	403 (15.86)	670 (26.38)	42 (1.65)	20
600 mm PN 10	685 (26.97)	390 (15.36)	914 (36.00)	885 (34.85)	823 (32.39)	461 (18.14)	725 (28.54)	30 (1.18)	20
600 mm PN 16	725 (28.54)	420 (16.54)	914 (36.00)	877 (34.51)	823 (32.39)	461 (18.14)	770 (30.31)	36 (1.42)	20
600 mm PN 25	720 (28.35)	423 (16.64)	914 (36.00)	877 (34.51)	823 (32.39)	461 (18.14)	770 (30.31)	39 (1.54)	20
600 mm PN 40	735 (18.94)	445 (17.52)	1,007 (39.64)	886 (34.88)	823 (32.39)	461 (18.14)	795 (31.30)	48 (1.88)	20

Dimensions with DIN Flanges

(1) Consult factory for larger line sizes.

(2) When grounding rings (2 rings per meter) are specified, add 6.35 mm (0.25 in.) for 15 mm through 350 mm (½- through 14 in.) flowtubes or 12.7 mm (0.50 in.) for 400 mm (16 in.) and larger. When lining protectors are specified, add 6.35 mm (0.25 in.) for 15 mm through 300 mm (½- through 12-in.) flowtubes, 12.7 mm (0.50 in.) for 350 mm through 900 mm (14- through 36-in.) flowtubes.

Figure 4-3. Dimensional Drawing of Model 8705 Sanitary Flowtubes,
Typical of 1/2- through 3-inch (15 through 86 mm) Line Sizes with Option Code W0, Housing Configuration



NOTES
Dimensions are in inches (millimeters).
See Table 7 for variable dimensions.

Hazardous Location Certifications

N0 Factory Mutual (FM) Approval Dust-ignition proof for Class II/III, Division 1 Groups E, F, and G; Non-incendive for Class I, Division 2 Groups A, B, C, and D; T5 temperature code; For non-flammable process fluid service only
AND
Canadian Standards Association (CSA) Approval Suitable for use in Class I, Division 2 Groups A, B, C, and D; Dust-ignition proof for Class II/III, Division 1, Groups E, F, and G hazardous locations
AND
CE Marking.

N5 Factory Mutual (FM) Approval; Dust-ignition proof for Class II/III, Division 1 Groups E, F, and G hazardous locations; Non-incendive for Class I, Division 2 Groups A, B, C, and D; T5 temperature code; For flammable process fluid service

E5 Factory Mutual (FM) Approval Explosion Proof for Class I, Division 1, Groups C and D; T6 temperature code; flammable process fluid service; Available for remote mount transmitter or integral mount Model 8732C transmitters

CD KEMA/CENELEC Approval
EEx e ia IIC T3...T6 (See Table 5-1)

Conductivity Limits

Process liquid must have a conductivity of 5 microsiemens/cm (5 micromhos/cm) or greater for Model 8711. Excludes the effect of interconnecting cable length in remote mount transmitter installations

TABLE 5-1. Relation Between Ambient Temperature, Process Temperature, and Temperature Class(1)

Meter Size (inches)	Maximum Ambient Temperature	Maximum Process Temperature	Temperature Class
1/2	149 °F (65 °C)	240 °F (116 °C)	T3
1	149 °F (65 °C)	248 °F (120 °C)	T3
1	95 °F (35 °C)	95 °F (35 °C)	T4
1 1/2	149 °F (65 °C)	257 °F (125 °C)	T3
1 1/2	140 °F (60 °C)	140 °F (60 °C)	T4
2	149 °F (65 °C)	257 °F (125 °C)	T3
2	149 °F (65 °C)	167 °F (75 °C)	T4
2	104 °F (40 °C)	104 °F (40 °C)	T5
3 - 4	149 °F (65 °C)	266 °F (130 °C)	T3
3 - 4	149 °F (65 °C)	167 °F (75 °C)	T4
3 - 4	131 °F (55 °C)	194 °F (90 °C)	T5
3 - 4	104 °F (40 °C)	104 °F (40 °C)	T6
6	149 °F (65 °C)	175 °F (79 °C)	T3
6	149 °F (65 °C)	167 °F (75 °C)	T4
6	149 °F (65 °C)	230 °F (110 °C)	T5
6	140 °F (60 °C)	140 °F (60 °C)	T6
8 - 36	149 °F (65 °C)	284 °F (140 °C)	T3
8 - 36	149 °F (65 °C)	240 °F (116 °C)	T4
8 - 36	149 °F (65 °C)	176 °F (80 °C)	T5
8 - 36	149 °F (65 °C)	149 °F (65 °C)	T6

(1) This table applicable for KEMA/CENELEC approval only.

Studs, Nuts, and Washers[1]

ASME B16.5 (ANSI)

Line sizes 0.15- through 1-inch (4 through 25 mm):
316 SST, ASTM A193, Grade B8M, Class 1 threaded mounting studs; ASTM A194, Grade 8M heavy hex nuts; SAE per ANSI B18.2.1, Type A, Series N flat washers

Line sizes 1.5- through 8-inch (40 through 200 mm):
CS, ASTM A193, Grade B7, Class 1 threaded mounting studs; ASTM A194, Grade 2H heavy hex nuts; SAE per ANSI B18.2.1, Type A, Series N flat washers; all items clear, chromate zinc-plated

DIN

Line sizes 4 through 25 mm (0.15- through 1-inch):
316 SST ASTM A193, Grade B8M Class 1 threaded mounting studs; ASTM A194, Grade 8M, DIN 934 H=D, metric heavy hex nuts; 316 SST, A4, DIN 125 flat washers

Line sizes 40 through 200 mm (1.5- through 8-inch):
CS, ASTM A193, Grade B7 threaded mounting studs; ASTM A194, Grade 2H, DIN 934 H=D, metric heavy hex nuts; CS, DIN 125 flat washers; all items yellow zinc-plated

Electrical Connections

Two ¾–14 NPT connections with number 8 screw terminals are provided in the terminal enclosure for electrical wiring.

Grounding Electrode

A grounding electrode is installed similarly to the measurement electrodes through the flowtube lining. It is available in all electrode materials.

Grounding Rings

Grounding rings are installed between the flange and the tube face on both ends of the flowtube. They have an I.D. slightly larger than the flowtube I.D. and an external tab to attach ground wiring. Grounding rings are available in 316L SST, Hastelloy C-276, titanium, and tantalum.

Flowtube Dimensions and Weight

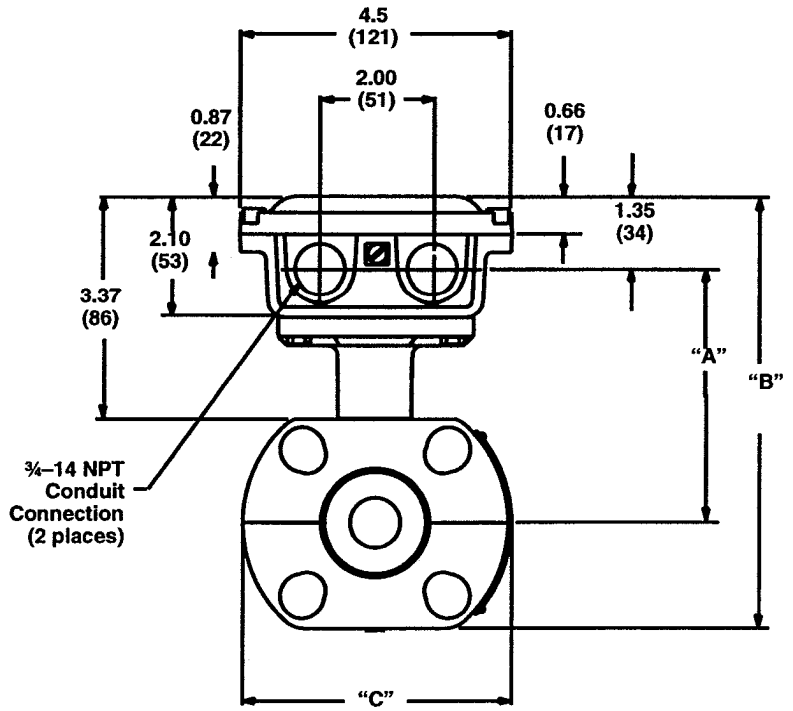
See Table 1

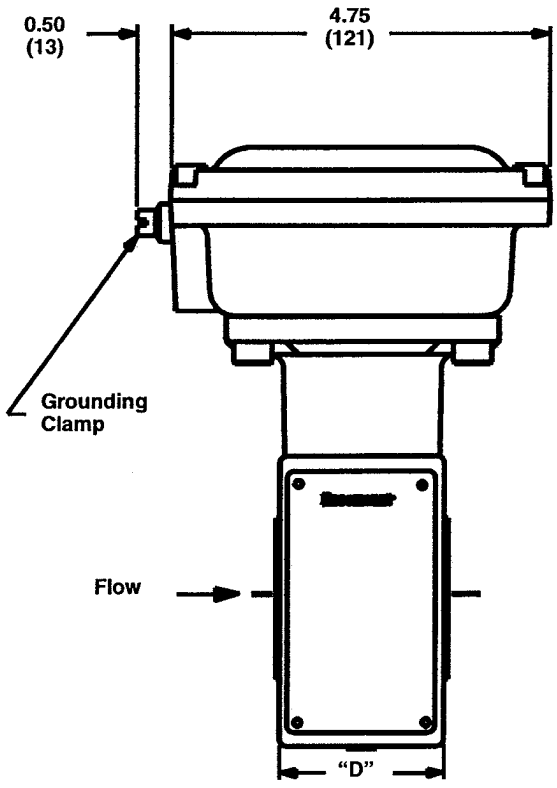
TABLE 1. Flowtube Dimensions and Weight

Nominal Line Size Inches (mm)		Flowtube Housing Dimensions "A" Max.		"B"		"C"		Flowtube Length "D"		Inside Diameter		Weight lb (kg)	
0.15	(4)	4.00	(102)	5.44	(138)	3.56	(90)	2.17	(55)	.165	(4)	4	(2)
0.30	(8)	4.00	(102)	5.44	(138)	3.56	(90)	2.17	(55)	.287	(7)	4	(2)
0.5	(15)	4.00	(102)	5.44	(138)	3.56	(90)	2.17	(55)	.595	(15)	4	(2)
1	(25)	4.31	(109)	6.06	(154)	4.50	(114)	2.17	(55)	.959	(24)	5	(2)
1.5	(40)	4.42	(112)	7.41	(188)	3.28	(83)	2.73	(69)	1.50	(38)	5	(2)
2	(50)	4.64	(118)	7.94	(202)	3.91	(99)	3.26	(83)	1.95	(50)	7	(3)
3	(80)	5.26	(134)	9.19	(233)	5.16	(131)	4.68	(119)	2.98	(76)	13	(6)
4	(100)	5.87	(149)	10.41	(264)	6.38	(162)	5.88	(149)	3.90	(99)	22	(10)
6	(150)	6.97	(177)	12.60	(320)	8.56	(217)	6.87	(174)	5.825	(148)	35	(16)
8	(200)	8.00	(2003)	14.66	(372)	10.63	(270)	8.86	(225)	7.87	(200)	60	(27)

(1) 0.15 and 0.30 inch (4 and 80 mm) flowtubes mount between ½-inch (13 mm) flange.

Figure 5-2. Model 8711 Dimensional Drawings (0.15-inch through 1-inch line sizes).





NOTE
Dimensions are in inches (millimeters). See Table 1 for variable dimensions.

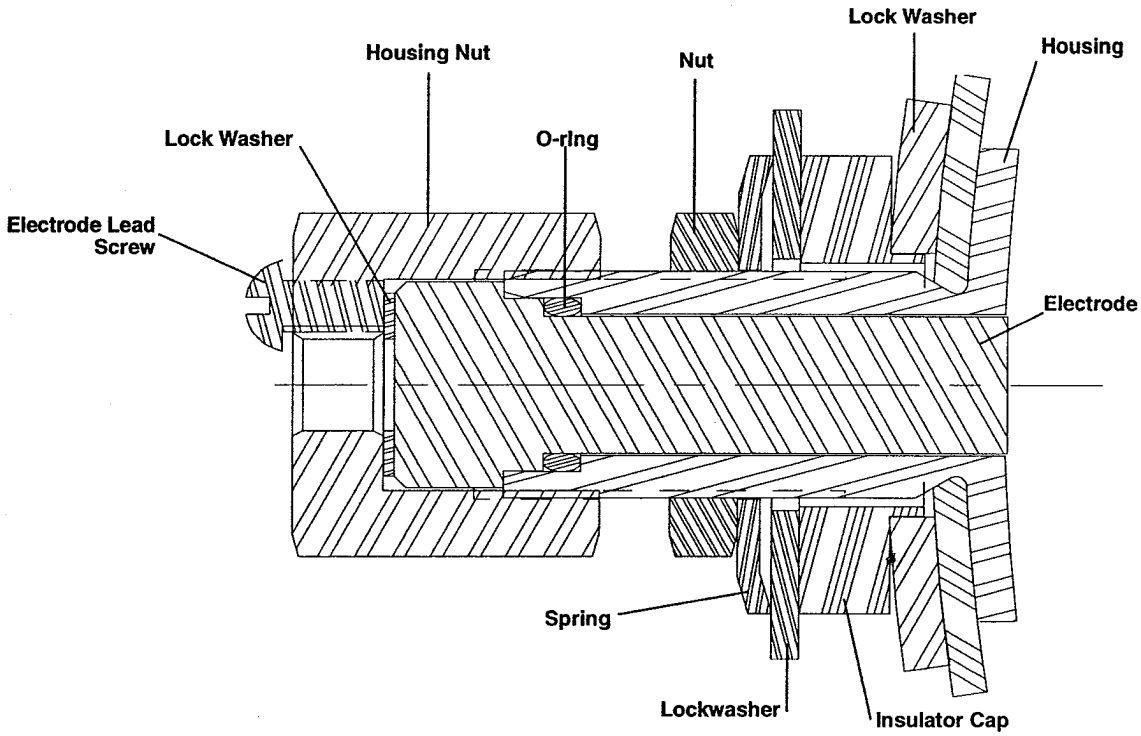
8711-1012B03A, 1012A03A

REPLACE THE ELECTRODE ASSEMBLY

Use the following procedure to replace the electrode assembly into the flowtube.

1. Lubricate the o-ring.
2. Install the o-ring on the electrode.
3. Insert the electrode into the electrode housing. Push straight in until the electrode is seated. Avoid rotating the electrode or the electrode housing as this could result in leakage.
4. Secure the electrode into the housing with the retaining nut and lock washer. Tighten the retaining nut to 15 in/oz of torque. Failure to tighten the fasteners can cause loss of liquid tight seal and result in damage to the unit.
5. Secure the signal wire to the electrode with the electrode lead screw.
6. Install the o-ring into the electrode cover.
7. Secure the electrode cover to the flowtube with the screws.

FIGURE A-1.
The Field-Replaceable Electrode



This document is available electronically at www.rosemount.com.

Rosemount Inc.
8200 Market Boulevard
Chanhassen, MN 55317 USA
Tel 1-800-999-9307
Fax (952) 949-7001

Fisher-Rosemount Flow
Groeneveldselaan 6-8
3909 AZ
3900 AB Veenendaal
The Netherlands
Tel 31 (0) 318 549 549
Fax 31 (0) 318 549 559

Fisher-Rosemount
Singapore PTE LTD
1 Pandan Crescent
Singapore 128461
Tel 31 (65) 777-8211
Fax 31 (65) 777-0947
email: AP.RMT-Specialist@frco.com

http://www.rosemount.com

00809-0100-4727 Rev. DA 4/00

ROSEMOUNT®
FISHER-ROSEMOUNT™

TABLE 1- FLOWTUBE MODEL SELECTION

MODEL 8705	MAGMETIC FLOWTUBE

CODE	LINING MATERIAL
T	PTFE (TEFLON)
F	ETFE (TEFZEL)
P	POLYURETHANE
N	NEOPRENE
L	LINATEX

} AVAILABLE IN 1-1/2 THROUGH 36 INCH (40-900 mm) LINE SIZES.

CODE	ELECTRODE MATERIAL
S	316L STAINLESS STEEL
T	TANTALUM
P	PLATINUM-10% IRIDIUM
H	HASTELLOY C-276
N	TITANIUM
C	CARPENTER 20
R	316 SST
B	HASTELLOY B
Z	ZIRCONIUM
W	TUNGSTEN CARBIDE COATED 316L
A	HAYNES ALLOY 25B
K	NICKEL
M	MONEL

CODE	ELECTRODE CONSTRUCTION
A	TWO ELECTRODES
E	TWO ELECTRODES, PLUS ONE GROUND ELECTRODE
R	TWO FIELD-REPLACEABLE ELECTRODES (NOT AVAILABLE ON 1/2-1 INCH. 1.5-4 INCH NO SEALED ELECTRODE COMPARTMENT AVAILABLE ACCESS ONLY)
B	TWO BULLET SHAPED ELECTRODES

CODE	LINE SIZE
005	.50" (15)
010	1.00" (25)
015	1.50" (40)
020	2.00" (50)
030	3.00" (80)
040	4.00" (100)
060	6.00" (150)
080	8.00" (200)
100	10.00" (250)
120	12.00" (300)
140	14.00" (356)
160	16.00" (406)
180	18.00" (457)
200	20.00" (508)
240	24.00" (610)
300	30.00" (762)
360	36.00" (914)

CODE	FLANGE MATERIAL
P	SST 316L
C	CARBON STEEL
S	STAINLESS STEEL 304

CODE	FLANGE RATING
1	ANSI CLASS 150
3	ANSI CLASS 300
6	ANSI CLASS 600
7	ANSI CLASS 600 (FULL RATED)
D	DIN PN 10
E	DIN PN 16
F	DIN PN 25
H	DIN PN 40

CODE	OPTIONS
G	GROUNDING RINGS
L	LINING PROTECTOR

CODE	OPTIONS
1	316L SST
2	HASTELLOY C-276
3	TITANIUM
4	TANTALUM (GROUNDING RING ONLY)
5	316L WITH 304SST RETAINING RING
6	HASTELLOY C-276 WITH 304 SST RETAINING RING

CODE	OPTIONS
W1	ALL WELDED HOUSING (DOES NOT INCLUDE SEALED ELECTRODE COMPARTMENTS) NOT AVAILABLE WITH FIELD REPLACEABLE ELECTRODES (OPTIONS CODE R) OR IN 1/2 OR 1 INCH (15 OR 25mm) SIZES.
W3	ALL WELDED HOUSING WITH SEALED ELECTRODE COMPARTMENTS
H1	FLOWTUBE WITH MODEL 8701 LAY LENGTH 1/2-4". SPOOL PIECE
B1	INTEGRAL MOUNT WITH MODEL 8712C TRANSMITTER
B3	INTEGRAL MOUNT WITH MODEL 8732C TRANSMITTER
KD	KEMA/CENELEC APPROVAL
04	CALIBRATION DATA SHEET
08	MATERIAL CERTIFICATE OF CONFORMANCE ISO 10474-3.1B
09	MATERIAL CERTIFICATE OF CONFORMANCE ISO 10474-3.1B ELECTRODES ONLY
A3	3A SANITARY APPROVAL WITH TRI CLAMP ADAPTERS (AVAILABLE OR .50-3 IN. W1 OPTION ONLY)
A4	SANITARY 3A FOR ANSI 150 TO TRI-CLAMP (2 INCH SIZE ONLY)
A5	CHERRY BURRELL SANITARY 1-LINE (1/2 to 3 INCH (15 TO 80 mm) SIZES
A6	CHERRY BURRELL SANITARY 1-LINE (2 1/2 INCH (64 mm) ONLY)

8705	T	S	A	040	C	1	G	1	Q4	← TYPICAL MODEL NUMBER

ROSEMOUNT® INC.
MINNEAPOLIS, MINN.

ISSUE	DR

THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES.

SIZE	FSCM NO.	DRAWING NO.
A	04274	08705-0026

FILE NAME:

SCALE:	WT.	SHEET 2 OF 8

TABLE 2

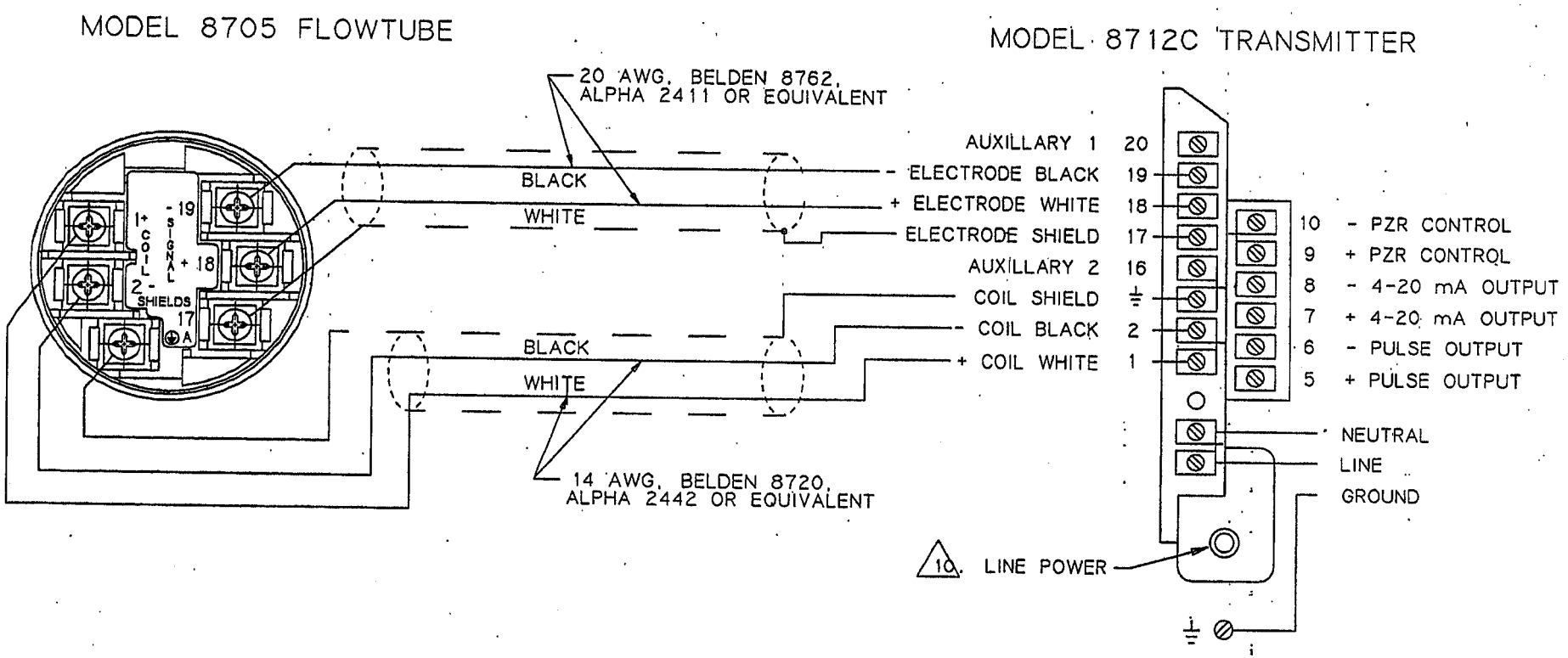
METER SIZE	OVERALL LENGTH ±.16 (4.1)				FLANGE DIA.	BODY DIAMETER	CL TO UMB MOUNT PAD	BODY WIDTH	BOLT HOLE CIRCLE DIA.	BOLT HOLE DIAMETER	RAISED FACE DIAMETER	NO. OF EQUALLY SPACED BOLT HOLES	FLOW TUBE WEIGHT	H1 OPTION LAY LENGTH
	DIM "A" w/Teflon	DIM "A" w/Tefzel	DIM "A" w/Neoprene/ Gum Rubber	DIM "A" w/Polyurethane	DIM "B" (REF)	DIM "C" ±.10 (2.5)	DIM "D" ±.20 (5.1)	DIM "E" ±.15 (3.8)	DIM "G" ±.06 (1.5)	DIM "H" ±.02 (.5)	DIM "J" ±.06 (1.5)			
18.0" (450mm), 150lb	27.00 (685.8)	26.87 (682.5)	26.97 (685.0)	27.00 (685.8)	25.00 (635.0)	23.46 (595.9)	14.10 (358.1)	25.82 (655.8)	22.75 (577.9)	1.25 (31.8)	21.00 (533.4)	16	600 (273)	H1 OPTION IS NOT APPLICABLE FOR LINE SIZES OVER 16"
18.0" (450mm), 300lb	30.12 (765.0)	30.00 (762.0)	30.09 (764.3)	30.12 (765.0)	28.00 (711.2)				24.75 (628.7)	1.38 (35.1)	21.00 (533.4)	24	1010 (460)	
20.0" (500mm), 150lb	30.00 (762.0)	29.80 (756.9)	30.00 (762.0)	30.00 (762.0)	27.50 (698.5)	25.48 (647.2)	15.11 (383.8)	27.84 (707.1)	25.00 (635.0)	1.25 (31.8)	23.00 (584.2)	20	680 (309)	
20.0" (500mm), 300lb	33.25 (844.6)	33.06 (839.7)	33.16 (842.3)	33.25 (844.6)	30.50 (774.7)				27.00 (685.8)	1.38 (35.1)	23.00 (584.2)	24	1180 (537)	
20.0" (500mm), PN 10	30.00 (762.0)	29.80 (756.9)	30.00 (762.0)	30.00 (762.0)	26.38 (670.1)				24.41 (620.0)	1.02 (25.9)	23.03 (585.0)	20	680 (309)	
20.0" (500mm), PN 16	30.00 (762.0)	29.80 (756.9)	30.00 (762.0)	30.00 (762.0)	28.15 (715.0)				25.59 (650.0)	1.30 (33.0)	24.02 (610.1)	20	680 (309)	
20.0" (500mm), PN 25	30.00 (762.0)	29.80 (756.9)	30.00 (762.0)	30.00 (762.0)	28.74 (730.0)				25.98 (659.9)	1.42 (36.1)	24.21 (614.9)	20	680 (309)	
20.0" (500mm), PN 40	33.25 (844.6)	33.06 (839.7)	33.16 (842.3)	33.25 (844.6)	29.72 (754.9)				26.38 (670.1)	1.65 (41.9)	24.21 (614.9)	20	1180 (537)	
24.0" (600mm), 150lb	36.00 (914.4)	35.77 (908.6)	36.00 (914.4)	36.00 (914.4)	32.00 (812.8)	30.03 (762.8)	17.39 (441.7)	32.39 (822.7)	29.50 (749.3)	1.38 (35.1)	27.25 (692.2)	20	1000 (455)	
24.0" (600mm), 300lb	39.64 (1006.9)	39.40 (1000.8)	39.63 (1006.6)	39.64 (1006.9)	36.00 (914.4)				32.00 (812.8)	1.62 (41.1)	27.25 (692.2)	24	1865 (848)	
24.0" (600mm), PN 10	36.00 (914.4)	35.77 (908.6)	36.00 (914.4)	36.00 (914.4)	30.71 (780.0)				28.54 (724.9)	1.18 (30.0)	26.97 (685.0)	20	1000 (455)	
24.0" (600mm), PN 16	36.00 (914.4)	35.77 (908.6)	36.00 (914.4)	36.00 (914.4)	33.07 (840.0)				30.31 (769.9)	1.42 (36.1)	28.54 (724.9)	20	1000 (455)	
24.0" (600mm), PN 25	36.00 (914.4)	35.77 (908.6)	36.00 (914.4)	36.00 (914.4)	33.27 (845.1)				30.31 (769.9)	1.54 (39.1)	28.35 (720.1)	20	1000 (455)	
30.0" (750mm), 125 lb	37.25 (946.2)	37.25 (946.2)	37.25 (946.2)	37.25 (946.2)	38.75 (984.3)	35.50 (901.7)	20.56 (522.2)	38.50 (977.9)	36.00 (914.4)	1.38 (35.1)	33.8 (858.5)	28	1400 (637)	
36.0" (900mm), 125 lb	40.75 (1035.1)	40.75 (1035.1)	40.75 (1035.1)	40.75 (1035.1)	46.00 (1168.4)	45.36 (1101.7)	24.50 (622.3)	46.38 (1178.1)	42.75 (1085.9)	1.63 (41.4)	40.27 (1022.9)	32	1975 (898)	

ROSEMOUNT® INC.
MINNEAPOLIS, MINN.

DR	
ISSUE	

THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES.
FILE NAME:

SIZE	FSCM NO.	DRAWING NO.
A	04274	08705-0026
SCALE:	WT.	SHEET 4 OF 8



10 1 AMP FOR 115 VAC SYSTEM, 1/2 AMP FOR 230 AC SYSTEM AND 3 AMP FOR 10-30V dc SYSTEMS. USE QUICK ACTING BUSSMAN AGCI OR EQUIVLANT.

11. CONSULT PRODUCT MANUAL FOR DETAILED INFORMATION ON INSTALLATION, OPERATION, OR MAINTENANCE. FAILURE TO DO SO COULD RESULT IN PERSONAL INJURY OR DAMAGE TO PRODUCT OR PROPERTY.

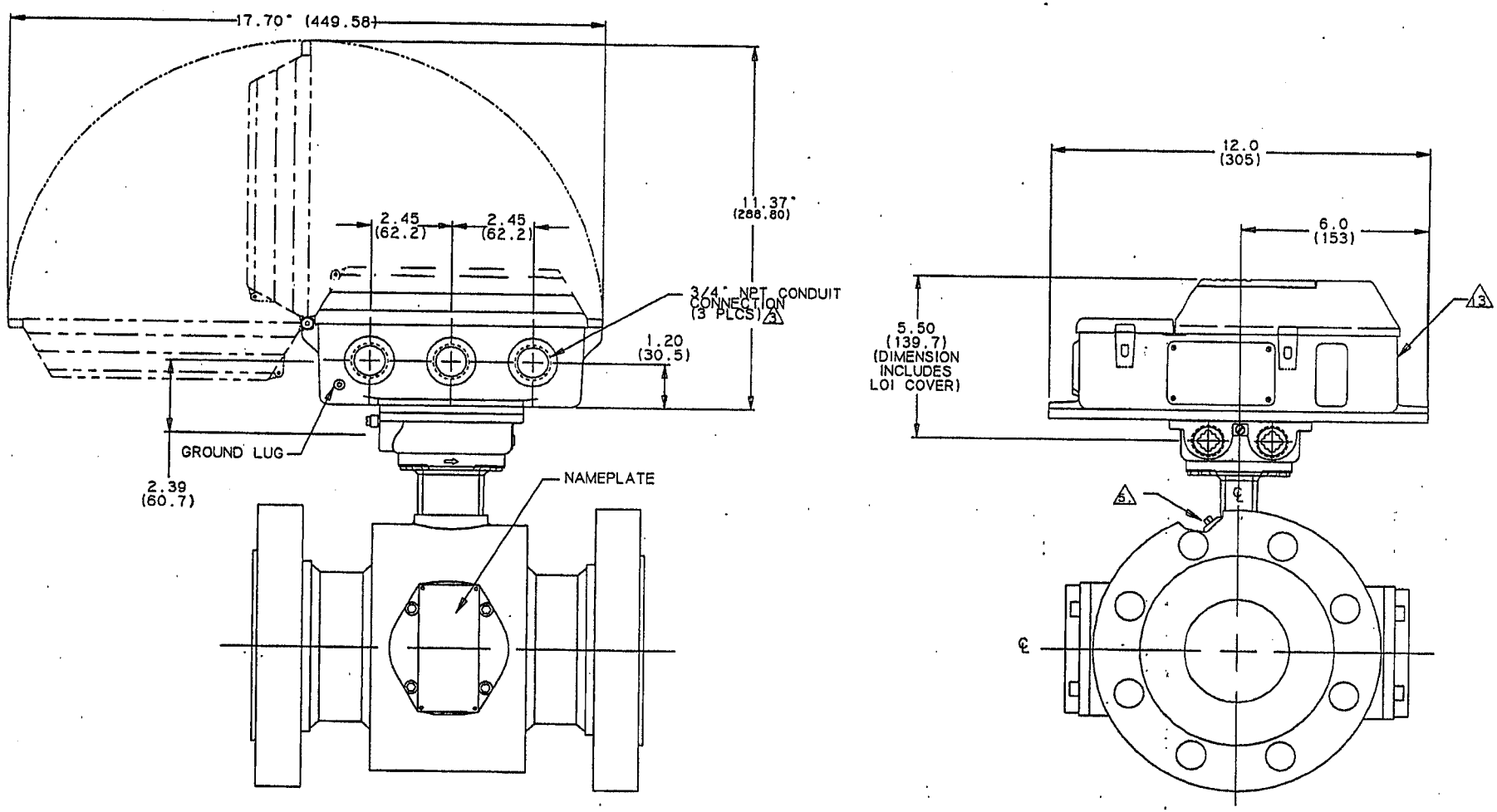
12. TRANSMITTER TO FLOW TUBE WIRING MAY BE WIRED THRU SINGLE CONDUIT OPENING. BOTH CABLES MUST BE SHIELDED.

ROSEMOUNT INC.
MINNEAPOLIS, MINN.

DR	
ISSUE	

THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES.
FILE NAME:

SIZE	FSCM.NO.	DRAWING NO.
A	04274	08705-0026
SCALE:	WT.	SHEET 5 OF 8



INTEGRAL MOUNT WITH 8712 C/U

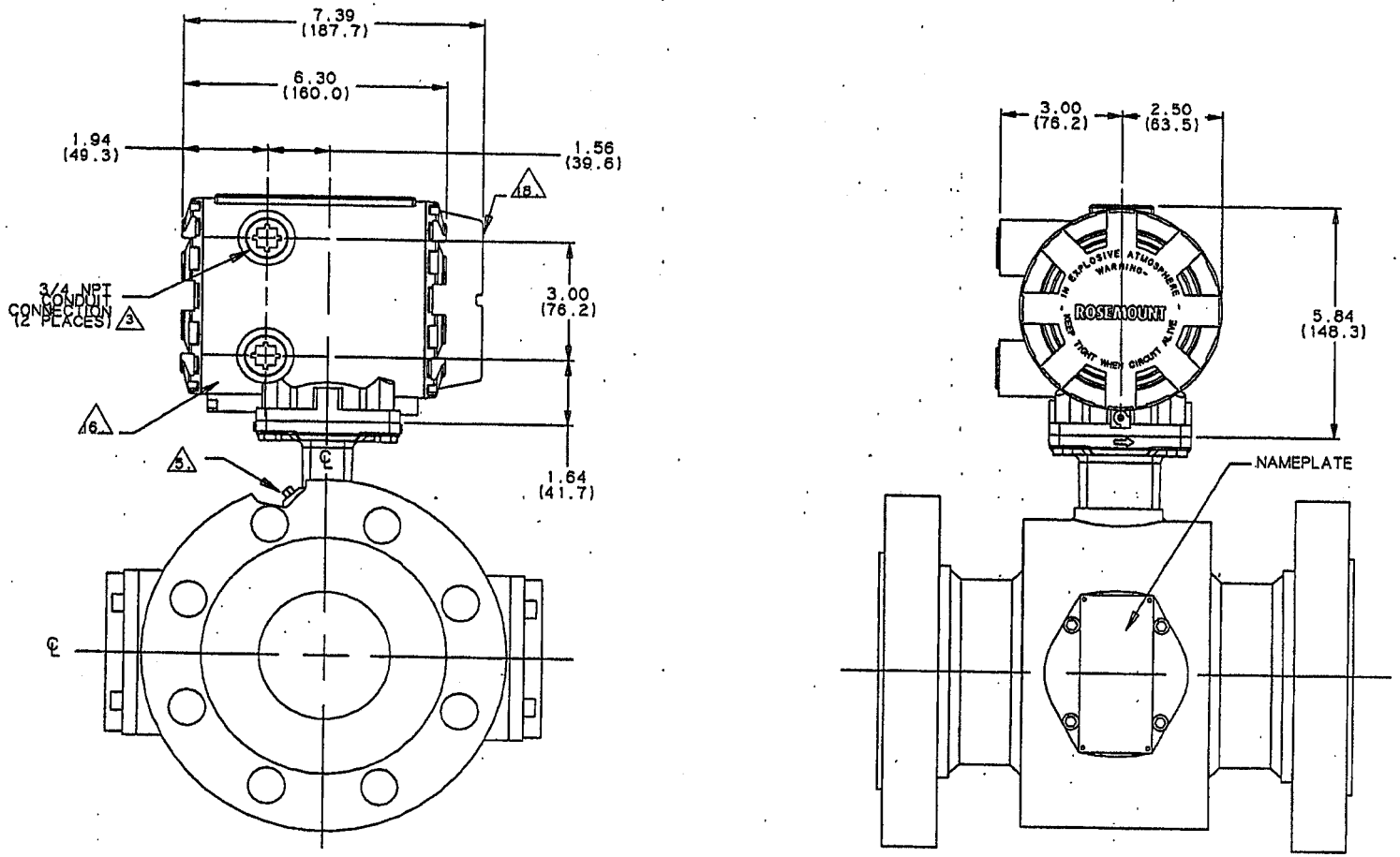
15. ADD 3lbs. TO TRANSMITTER FOR INTEGRAL MOUNT
14. REFRANCE SHEETS 1-4 FOR FLOWTUBE DIMENSIONS.
13. TRANSMITTER CAN BE INTEGRALLY MOUNTED IN 90 DEGREE INCREMENTS.

ROSEMOUNT INC.
MINNEAPOLIS, MINN.

DR	
ISSUE	

THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES.
FILE NAME:

SIZE	FSCM.NO.	DRAWING NO.
A	04274	08705-0026
SCALE:	WT.	SHEET 6 OF 8



INTEGRAL MOUNT WITH 8732C

8. OPTIONAL LOCAL OPERATOR INTERFACE (M4 OPTION).

17. REFRANCE SHEETS 1-4 FOR FLOWTUBE DIMENSIONS.

6. TRANSMITTER CAN BE INTEGRALLY MOUNTED IN 90 DEGREE INCREMENTS.

ROSEMOUNT INC. MINNEAPOLIS, MINN.	THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES. FILE NAME:
DR	SIZE A / FSCM.NO. 04274 / DRAWING NO. 08705-0026
ISSUE	SCALE: / WT. / SHEET 7 OF 8

TABLE 3 - TRANSMITTER MODEL SELECTION

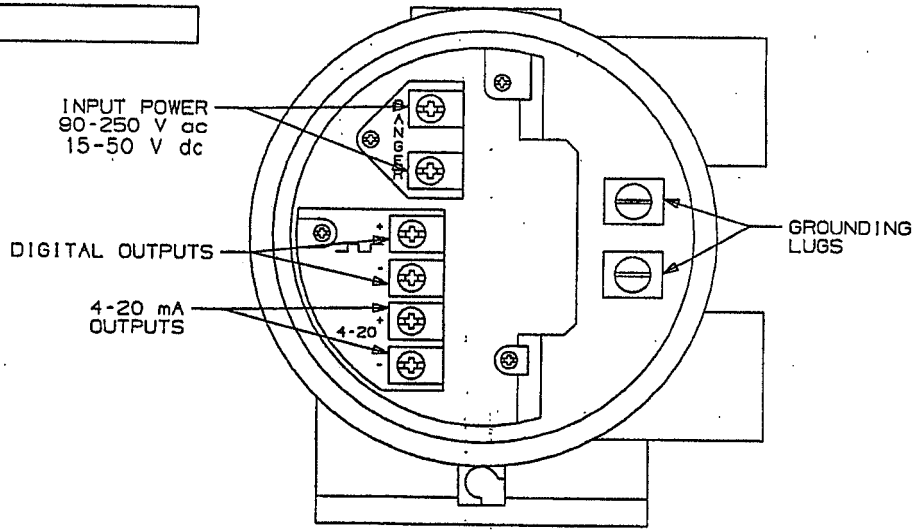
MODEL 8732C	MAGNETIC FLOWMETER TRANSMITTER

CODE	TRANSMITTER STYLE
T	INTEGRAL (MOUNTED TO MODELS 8705 OR 8711 FLOWTUBES ONLY)

CODE	POWER SUPPLY VOLTAGE
12	90-250 V ac
03	15-50 V dc

CODE	OPTIONS
ED	KEMA/CENELEC APPROVALS
E5	FACTORY MUTUAL (FM) APPROVALS, CLASSI, DIVISION1
E6	CSA APPROVALS, CLASSI, DIVISION1
M4	LOCAL OPERATOR INTERFACE
C1	CUSTOM CONFIGURATION
T1	NON-VOLATILE TOTALIZER
L1	TRANSIENT PROTECTION CIRCUITRY
J1	CM20 CONDUIT ADAPTERS
J2	PG 13.5 CONDUIT ADAPTERS
D1	HIGH-ACCURACY CALIBRATION

8732C T 12 ED ← TYPICAL MODEL NUMBER



THIS DRAWING WAS CREATED ON CAD. VELLUM MASTER IS NOT TO BE CHANGED. DRAWING IS ARCHIVED ON MAGNETIC TAPE FOR ECO CHANGES.

FILE NAME:

ROSEMOUNT INC.
MINNEAPOLIS, MINN.

DR	SIZE	FSCM.NO.	DRAWING NO.
ISSUE	A	04274	08705-0026
	SCALE:	WT.	SHEET 8 OF 8