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Office of Solid Waste and Emergency Response
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Technology Innovation

Optimization Review
French Gulch/Wellington-Oro Mine Site
Water Treatment Plant

Breckenridge, Summit County, Colorado

www.epa.gov/superfund/remedytech | www.clu-in.org/optimization | www.epa.gov/superfund/cleanup/postconstruction

OPTIMIZATION REVIEW

FRENCH GULCH/WELLINGTON-ORO MINE SITE
WATER TREATMENT PLANT
BRECKENRIDGE, SUMMIT COUNTY, COLORADO

Report of the Optimization Review
Site Visit Conducted at the French Gulch/Wellington-Oro Mine Site
December 11, 2012

May 16, 2013

EXECUTIVE SUMMARY

Optimization Background

The U.S. Environmental Protection Agency's definition of optimization is as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."*[1]

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent review, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

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[1] EPA. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

Site-Specific Background

The French Gulch/Wellington-Oro Mine Site is located near the town of Breckenridge in Summit County, Colorado. Environmental contamination of surface water, groundwater, soil and sediment at the site resulted from mining activities dating to the 1880s. Site investigations have concluded that the underground workings (tunnels, adits, drifts, stopes and crosscuts) of the site constitute the largest source of metals loading to groundwater and surface water. An on-site seep, FG-6C, is the primary conduit of mine pool water into French Gulch. The surface water and groundwater remedy consists of the water treatment plant (WTP), which treats acid rock drainage (ARD) collected by pumping FG-6C. The WTP removes zinc and cadmium from FG-6C to improve surface water quality in French Gulch and the Blue River.

Summary of CSM

The CSM for the French Gulch/Wellington-Oro Mine Site was not reviewed as this optimization review focuses on the operations of the WTP.

Summary of Findings

Key findings from this optimization review include:

- Water from FG-6C flows year-round at a rate of approximately 50 gallons per minute (gpm). FG-6C water is pumped from a pump box/diversion weir to a 9,000-gallon feed buffer tank at a maximum rate of approximately 150 gpm for flow equalization and short-term storage. Any flow in excess of 150 gpm entering the pump box flows over the weir directly to French Gulch without treatment.

- Reagents used in the WTP include sodium hydrosulfide (NaHS), soda ash (Na_2CO_3) and flocculent.

- Since startup in 2008, the WTP has experienced a series of mechanical problems (primarily associated with the filters); these problems have caused frequent and extended periods of shutdown and failure to meet the effluent standards for discharge to surface water. During 2012, the WTP recycled partially-treated (99+ percent zinc removal) effluent to the mine for approximately 50 percent of the time it was operating.

- The pressure filters do not appear to have adequate controls or back flushing capabilities for proper upkeep of the media. Back flushing water is supplied from the effluent of other filters in operation rather than from a dedicated supply pump; this approach cannot provide enough flow to achieve effective back washing.

- The WTP building is compact and access around the equipment is severely constrained. In addition, during the site visit, the interior space was cluttered with spare parts and miscellaneous materials that were stacked due to a lack of storage space.

- During the site visit, the WTP building appeared to be poorly insulated and to have inadequate ventilation. The ambient air in the WTP has low levels of hydrogen sulfide (H_2S) from the process units.

- The WTP control system is a proprietary system provided by BioteQ Environmental Technologies, Inc. (BioteQ); this requires WTP staff to contact BioteQ whenever any system change is needed.

- There are level sensors on the tanks. However, during the site visit, there did not appear to be adequate local indicators for operators to be aware of the conditions in the tanks and of the processes to quickly monitor operating conditions. Therefore, tank levels are often unknown until overflows occur.

- The WTP typically operates at less than 50 percent of capacity and could treat ARD from additional seeps if they were identified.

- The WTP cannot meet the zinc standard (0.225 milligrams per liter [mg/L]) without filtration.

- Total annual operating costs (including equivalent labor costs) are $260,000. The major cost components are $104,000 for labor (using typical, standard loaded operator labor rates); $80,000 for maintenance/subcontractors; $41,500 for chemicals; $24,500 for utilities; and $10,000 for laboratory analyses. The maintenance costs are extremely high and represent a system that has ongoing, non-routine operating problems associated with the filters, soda ash addition and the overall building condition.

Summary of Recommendations

The following recommendations are provided to improve remedy effectiveness, reduce cost and provide technical improvement:

Improving effectiveness:

- Consider alternative filters or improve existing filters:

    - Consider retrofitting bag type filters to replace the existing pressure media filters to reduce overall operator time associated with filter maintenance and allow the WTP to operate at a much higher percent up-time. A simple test of bag filter capacity can be performed to determine how frequently the bags would have to be replaced. If bag replacement is infrequent, bag filtration will be more cost-effective than the multi-media filters (with associated backwash and associated maintenance). A pilot test using a small capacity filter could be conducted for approximately $5,000. If the pilot test indicates that adequate metals removal can be achieved with reasonable bag filter use (for example replacing the bag filters weekly or less frequently), conversion to a four-plex bag filter system could be accomplished for approximately $30,000.

    - If the existing filters are kept in service, several improvements should be considered:

        - Provide individual differential pressure monitors on each filter.
        - Install a pressure indicator upstream of the existing pressure maintaining valve to help ensure that the valve is operating correctly.
        - Consider adding orifice plates in the effluent lines from each filter for better flow distribution between the filters.

        - Consider having a standby skid of four filters that are already charged with the media; these would be available for immediate replacement if the inline filters become clogged and require media replacement.
        - Consider adjusting the pH after (rather than before) the filters. This may reduce the potential for clogging the media.
        - Continue using muriatic acid to clean the filter media on a routine basis.

- Consider soda ash system changes:

    - Consider using sodium hydroxide (NaOH; caustic soda) as an alternative for pH control throughout the process. The existing soda ash system is a constant source of mechanical problems related to pipe clogging or scaling. Also, daily flushing with hot water requires considerable labor and energy expense. Adding a caustic soda system would include a drum feed system and metering pumps. The existing soda ash solution piping could be used to feed caustic soda. The cost for furnishing and installing a caustic soda feed system would be approximately $10,000.

- Develop a plan for meeting standards at the point of compliance:

    - Determine if treating FG-6C is improving water quality in French Gulch and the Blue River and to what degree based on surface water sampling results.

Reducing cost:

- Provide natural gas service for heating. Natural gas heating would offer savings of approximately 80 percent compared to propane. The cost to provide service to the WTP should be investigated; with long-term WTP operation likely, even a $25,000 or higher cost for a 5-year plus payback period would be worthwhile.

Technical improvement:

- Improve tank level controls:

    - Consider retrofitting the filter feed and backflush tanks with magnetic float type sight glass level indicators to allow the operators a visual local indication of tank levels.

    - Consider keeping the feed buffer tank in service during routine operation for surge dampening.

- Improve building ventilation to reduce hydrogen sulfide (H_2S) fumes:

    - Consider modifying the ventilation system to bring outside air into the control room and electrical room and discharge into the operations area to protect electrical gear.

    - Consider installing individual in-line exhaust fans in the vent lines from each process unit currently leaking H_2S fumes to ensure a slight negative pressure in the headspace over each unit. These vent lines would then feed the existing H_2S scrubber system.

   - Consider using nitrogen in the sodium hydrosulfide (NaHS) storage tank as originally designed. This tank is likely the major source of H_2S fumes.

   - Consider improving heating in the chemical storage areas (insulating of the overhead door was completed in the winter of 2013).

- Standardize controls, maintenance, and parts:

   - Make immediate efforts to use standard, readily available equipment wherever possible and add or stock redundant parts. A high portion of operation and maintenance (O&M) cost is for maintenance including subcontracted services and parts. In addition, the WTP downtime is excessive.

   - Make programming and engineering changes to automate the plant to switch from "discharge" mode to "recycle to mine" mode. Operators currently manually change the position on two valves when the plant goes out of compliance (pH primarily) to send water from the discharge back to the feed buffer tank and to the mine. The "recycle to mine" option would allow the WTP to operate while the problem is resolved instead of shutting whole process down.

   - Consider converting the control system to commercially available control software that could be serviced or modified by local control system integrators and implement the proposed control change to include automated recycle to the mine to improve system operation.

   - Standardize process equipment and chemical feed and control components (pumps, probes, flow meters, level sensors, pressure sensors and switches, mixers) as feasible and or have spares readily available. For example, the oxidation-reduction potential (ORP) probes are indicated to be installed in a "hot tap assembly" for insertion and removal from a full tank. Consideration should be given to providing a "hot-swappable" arrangement so that another ORP probe can be immediately available at each location for change out with the actively installed probe. This allows immediate and quick replacement with no loss of signal.

Site closure:

No site closure recommendations are provided. The WTP operation is expected to continue indefinitely if it is determined that treating FG-6C water is effective in meeting the site's remedial action objectives (RAO). If treating FG-6C (and potentially adding a similar ARD source to be determined) is shown to have little or no effect on French Gulch and Blue River, continued long-term operation of the WTP should be reconsidered and source control alternatives should be re-examined.

NOTICE

Work described herein including preparation of this report was performed by Tetra Tech for the U.S. Environmental Protection Agency under Work Assignment #2-58 of EPA contract EP-W-07-078 with Tetra Tech, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the EPA Office of Superfund Remediation and Technology Innovation (OSRTI). The project contacts are as follows:

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
µg/L	micrograms per liter
Ag	silver
AMD	acid mine drainage
ARD	acid rock drainage
As	arsenic
Au	gold
BioteQ	BioteQ Environmental Technologies, Inc.
BMP	best management practices
Btu	British thermal unit
ccf	hundred cubic feet
Cd	cadmium
CdS	cadmium sulfide
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDPHE	Colorado Department of Public Health and the Environment
CO_{2e}	carbon dioxide equivalents of global warming potential
COC	contaminants of concern
CSM	conceptual site model
Cu	copper
DMR	discharge monitoring reports
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERT	Emergency Response Team
Fe	iron
ft^2	square feet
GHG	greenhouse gas
gpd	gallons per day
gpm	gallons per minute
H_2S	hydrogen sulfide
HAP	Total Hazardous Air Pollutant Emissions
HDPE	high-density polyethylene
KW	kilowatts
kWh	kilowatt hour
LTM	long-term monitoring
Mg	manganese
mg/L	milligrams per liter
NaHS	sodium hydrosulfide
Na_2CO_3	soda ash
NaOH	caustic soda
Ni	nickel
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
ORP	oxidation-reduction potential
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response

OU	operable unit
Pb	lead
PbS	lead sulfide
P&T	pump and treat
PM	particulate matter
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSE	remediation system evaluation
SEFA	Spreadsheets for Environmental Footprint Analysis
SOx	sulfur oxides
S.U.	standard units
TIFSD	Technology Innovation and Field Services Division
TDS	total dissolved solids
TSS	total suspended solids
USGS	United States Geological Survey
VFD	variable frequency drive
wt	weight
WTP	water treatment plant
Zn	zinc
ZnS	zinc sulfide

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001, independent site optimization reviews called Remediation System Evaluations (RSE) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies, as documented in *Office of Solid Waste and Emergency Response (OSWER) Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design and RSEs. The EPA's definition of optimization is as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."* [1]

As stated in the definition, optimization refers to a "systematic site review", indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (for example, focus on long-term monitoring [LTM] optimization or focus on one particular operable unit [OU]), but other site or remedy components are still considered to the degree that they affect the focus of the optimization. An optimization review considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (www.clu-in.org/greenremediation), and now routinely considers green remediation and environmental footprint reduction during optimization evaluations.

The optimization review included reviewing site documents, visiting the site for one day and compiling this report, which includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness

[1] EPA. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization review recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.

Purpose of Optimization at the French Gulch/Wellington-Oro Mine Site – Water Treatment Plant (WTP)

Environmental contamination of surface water, groundwater, soil and sediment occurred at the French Gulch/Wellington-Oro Mine Site as a result of mining activities. The surface water and groundwater remedy consists of the water treatment plant (WTP), which treats acid rock drainage (ARD) collected at the site by pumping a natural seep named FG-6C. ARD is acidic metal-laden water that results from oxidation of metal sulfides in rock surfaces exposed to air and water. Mining activities often expose previously buried mineralized rock to air and water initiating the generation of ARD. Acid mine drainage (AMD) refers to ARD strictly from mine disturbance. For the purposes of this report, the more general term ARD is used. The WTP removes zinc and cadmium from FG-6C in an attempt to improve surface water quality in French Gulch and the Blue River.

The site was selected by the EPA OSRTI for optimization review based on a nomination from the EPA's Abandoned Mine Lands Team. The optimization review is focused on current WTP operational effectiveness and efficiency. The optimization review includes discussion and evaluation of influent sources, metals mass loading, discharge criteria, solids handling and an operating cost breakdown. Other components of the site remedy are considered only as they relate to the WTP.

1.2 TEAM COMPOSITION

The optimization review team consisted of the following individuals:

Table 1: Optimization Review Team Composition

Name	Affiliation	Phone	Email
Peter Rich	Tetra Tech, Inc.	410-990-4607	Peter.Rich@tetratech.com
John Nemcik	Tetra Tech, Inc.	720-931-9307	John.Nemcik@tetratech.com
Doug Sutton*	Tetra Tech, Inc.	732-409-0344	Doug.Sutton@tetratech.com
Carolyn Pitera*	Tetra Tech, Inc.	703-390-0621	Carolyn.Pitera@tetratech.com

*Did not attend site visit.

In addition, the following individuals from EPA Headquarters and the EPA Environmental Response Team (ERT) participated in the optimization site visit:

- Steve Dyment, EPA Headquarters
- Gary Newhart, EPA ERT
- Tom Kady, EPA ERT

1.3 Documents Reviewed

The following documents were reviewed in support of the optimization review. The reader is directed to these documents for additional site information that is not provided in this report.

- *Quantification of Metals Loading in French Gulch*, USGS, July 1996
- *Ecological Risk Assessment for French Gulch/Wellington-Oro Mine Site*, EPA with Syracuse Research Corporation, May 2002
- *French Gulch Engineering Evaluation/Cost Analysis(EE/CA) Fact Sheet*, EPA/State of Colorado, June 3, 2002
- *Action Memorandum,* Victor Ketallapper, EPA, November 24, 2002
- *Action Memorandum Addendum #1*, Victor Ketallapper, EPA, November 30, 2004
- *Applicable or Relevant and Appropriate Requirements Compliance Document*, EPA and Colorado Department of Public Health and Environment, July 13, 2005
- *Consent Decree*, EPA and State of Colorado, 2005
- *Wellington-Oro Water Treatment Project Pre-Final Engineering Report*, BioteQ/Lyntek, January 30, 2007
- Record Construction Drawings of the WTP, Stantec Engineering, 2007
- *Operation and Maintenance Manual*, BioteQ, February 14, 2009
- Discharge monitoring reports and table, 2008-2012
- Daily reports, 2012
- Town of Breckenridge cost data, 2008-2012

1.4 Quality Assurance

This optimization review utilizes existing environmental data to evaluate remedy performance and to make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization review team before the data are used for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data and the use of the data in the optimization review. Data that are of suspect quality are either not used as part of the optimization review or are used with the quality concerns noted. Where appropriate, this report provides recommendations to improve data quality.

1.5 PERSONS CONTACTED

The following individuals associated with the site were present for the site visit:

Table 2: Persons Contacted During Optimization Review

Name	Affiliation	Email
Joy Jenkins	EPA Region 8	jenkins.joy@epa.gov
Steve Dyment	EPA Headquarters	dyment.stephen@epa.gov
Gary Newhart	EPA Environmental Response Team (ERT)	newhart.gary@epa.gov
Liz Fagen	EPA Region 8	fagen.elizabeth@epa.gov
Tom Kady	EPA ERT	kady.thomas@epa.gov
Mary Boardman	Colorado Dept. of Health and Environment (CDPHE)	mary.boardman@state.co.us
Carl Johnson	Town of Breckenridge	carlj@townofbreckenridge.com
Gary Roberts	Town of Breckenridge, Public Works, Water Manager	garyr@townofbreckenridge.com
Dale Stein	Town of Breckenridge, Public Works, Assistant Engineer	dales@townofbreckenridge.com
Laura Lynch	Town of Breckenridge, Public Works, Assist. Water Manager	laural@townofbreckenridge.com
Brian Lorch	Summit County, Open Space & Trails Director	brianl@co.summit.co.us

The Town of Breckenridge operates the WTP, including all collection and conveyance systems and site maintenance. Summit County funds the WTP operation jointly with the town. EPA and CDPHE oversee WTP operation and EPA monitors site-wide environmental media.

2.0 SITE BACKGROUND

This section is a summary based on information in the reviewed documents.

2.1 LOCATION

The French Gulch/Wellington-Oro Mine Site is located near the town of Breckenridge in Summit County, Colorado. The site is located approximately 2.2 miles upstream, east of the confluence of French Gulch and the Blue River. The Blue River is a Trophy Water trout stream and extremely important to the economy of Summit County. The French Gulch valley includes several abandoned mine and mill sites, the largest of which was the Wellington-Oro mining complex. The site location and a schematic of the French Gulch water treatment plant (WTP) with surface water sampling locations are shown on figures included in Appendix A.

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND FACILITY OPERATIONS

The majority of mining activities at the Wellington-Oro site occurred between the 1880s and 1930s; with some mining continuing until the 1970s. During those periods, lead (Pb), zinc (Zn), copper (Cu), silver (Ag) and gold (Au) ores were removed from over 12 miles of tunnels, adits, drifts, stopes and crosscuts, approximately half of which are below the elevation of the groundwater table. A 100-ton per day gravity mill operated at the site from 1908 until 1929 to concentrate Pb, Zn and pyrite. A 50-ton per day roaster and magnetic separation plant removed iron (Fe) and sulfur from the Zn ores from 1912 to 1927, when it was replaced by a more economical flotation mill.

The French Gulch valley floor was mined and dredged from the late 1850s to the 1940s, altering the valley topography and leaving behind large piles of boulders, cobbles and gravel.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

The EPA and the Colorado Department of Public Health and Environment (CDPHE) began investigations to determine the nature and extent of contamination at the Wellington-Oro Mine site in the late 1980s. An Engineering Evaluation/Cost Analysis (EE/CA) that focused on surface wastes containing elevated levels of Pb and arsenic (As) was completed in 1998. Subsequently, the EPA issued an action memorandum and administrative order to consolidate and cap the roaster fines, mill tailings and waste rock; and the work was performed in 1999. A second EE/CA that focused on the impact of metals being released from the site on the water quality in French Gulch and the Blue River was completed in 2002. This second EE/CA concluded that the underground workings (tunnels, adits, drifts, stopes and crosscuts) of the site constitute the largest source of metals loading to groundwater and surface water and that a natural seep, FG-6C, is the primary conduit of mine pool water into French Gulch. Zn and Cd were identified as the primary contaminants of concern (COCs).

In May 2002, EPA completed an Ecological Risk Assessment and subsequently issued an Action Memorandum in November 2002 and Addendum #1 in November 2004 to address water quality issues at the site. The actions stipulated in these documents, collectively referred to as the “Action Memorandum” are non-time critical response actions referred to as “Water Quality Action” providing for the collection and treatment of water at seep FG-6C. Removal actions and other stabilization measures were completed at several of the other mine sites in the French Gulch valley in the 2000s.

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

Dissolved metals in surface water in French Gulch downstream of the Wellington-Oro mine complex, especially Zn and Cd, are acutely toxic to fish and invertebrates. Concentrations of metals exceed benchmark levels in sediment associated with toxicity to benthic invertebrates. Groundwater is not used for potable purposes in the area, and past studies and risk assessments have not identified any significant human health risks.

2.4 EXISTING DATA AND INFORMATION

2.4.1 SOURCES OF CONTAMINATION

Drainage from flooded underground mine workings and seepage of leachate from surface tailings and mine waste piles are groundwater contaminant sources which in turn are the source of metals loading into French Gulch and the Blue River.

A 1996 United States Geological Survey (USGS) tracer test study concluded that the largest metals loading to French Gulch was from springs affected by drainage from the Wellington-Oro mine where the Bullhide Fault crosses the stream. Conflicting information exists regarding the relative contribution of surface leaching of metals from the mine waste rock, roaster fines and mill tailings. The site team is currently conducting studies to determine the relative contributions of the various sources.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

Local geology is comprised of bedrock ore with mineralized veins and metamorphic deposits associated with the historical lode mining at the site, which contributes to the generation of ARD and the other contaminant source materials listed in Section 2.4.1. Several north to northeast trending faults cut through the site area, including the Oro Fault Block, Wellington Fault Block, Great Northern and "J" Faults, Bullhide Fault and the 11-10 Fault.

At the western limit, the water level in the mine is above the level of French Gulch resulting in water discharges from the mine to the valley: (1) through faults and fractures that discharge to the alluvium; (2) as shallow alluvial groundwater flow; and (3) in the form of a series of springs which discharge mine-pool water all year round and intermittent springs located in dredge tailings piles that line the French Gulch valley floor.

Detailed discussion of the geology and hydrogeology of the site is beyond the scope of this review.

2.4.3 SOIL CONTAMINATION

Discussion of soil contamination at the site is beyond the scope of this review.

2.4.4 Soil Vapor Contamination

No soil vapor contamination is expected because the site contaminants are ARD-related and do not include volatile organic compounds.

2.4.5 Groundwater Contamination

Groundwater impacted by ARD including metals negatively impacts the surface water quality in French Gulch. The low pH typically associated with ARD is largely neutralized by limestone in the area. The detailed nature of the groundwater flow and its interaction with surface water are beyond the scope of this review.

Groundwater discharging at FG-6C is a key contributor to surface water contamination in French Gulch and the Blue River at the confluence with French Gulch. The percentage contribution from FG-6C has not been determined. The mass of Zn from the FG-6C seep is approximately 89 pounds per day (based on approximately 48 gallons per minute [gpm] at approximately 154 milligrams per liter [mg/L] Zn [averages from December 2008 to January 2012 discharge monitoring reports (DMRs)]).

2.4.6 Surface Water Contamination

Surface water drainage through the French Gulch valley flows from east to west, discharging to the Blue River. The Blue River then flows north for 10 miles, discharging to the Dillon Reservoir near the town of Frisco.

Surface water in French Gulch downstream of the Wellington-Oro mine and in a portion of the Blue River downstream of the mouth of French Gulch is impacted by levels of Zn and Cd that are toxic to aquatic life.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

The purpose of the Wellington-Oro Mine WTP is to treat a portion of the ARD collected at seep FG-6C, which is considered to be the main contributor of acid mine seepage in the area. The treatment objective is to reduce the Zn and Cd levels to the required effluent limits before discharging the effluent to French Gulch. The water treatment process consists of a metal precipitation and recovery circuit where inorganic sulfide is used as the precipitating agent. The WTP equipment components include a feed buffer tank, two contactors, a flocculation tank, a sludge conditioning tank, a clarifier, a filter press, a filter feed tank, four granular media pressure filters and a backflush tank. The process configuration is shown in a Process Flow Diagram included in Appendix A.

The following sections describe water collection and WTP features and operations.

3.1.1 COLLECTION

Seepage from FG-6C is collected by an underground drain system and flows to the pump box/diversion weir. From there it is pumped to the feed buffer tank in the WTP at a maximum rate of approximately 150 gpm. The feed buffer tank has a capacity of 9,000 gallons and provides some flow equalization and short-term storage of the feed water. If the plant is down for any reason, the water from the pump box can be pumped (“recycled”) back to the mine. Any flow in excess of 150 gpm entering the pump box flows over the diversion weir directly to French Gulch without any treatment. The FG-6C seep flows year-round at a rate of approximately 50 gpm.

3.1.2 WATER TREATMENT PLANT

3.1.2.1. Chemical Additions

Reagents used in the WTP include sodium hydrosulfide (NaHS), soda ash (Na_2CO_3), and flocculent. NaHS is delivered as a 35-44 percent solution and Na_2CO_3 and flocculent are prepared as solutions from dry reagent of strength suitable for plant operation. Although the use of nitrogen was included in the original design to minimize the release of hydrogen sulfide (H_2S) into the atmosphere, that element of the system was never constructed. All reagents are metered to the process using automated control systems.

3.1.2.2. Sludge Conditioning Tank, Contactors and Clarifier

The feed water is pumped to contactor TK-201 and flows by gravity to the second contactor, TK-200. Each contactor has 1,845 gallons of working volume. Sludge from the clarifier is returned to the sludge conditioning tank where the NaHS is added. The NaHS reacts with the recycled sludge and is available for reacting with the influent Cd and Zn inTK-201. The sludge conditioning tank effluent combines with the raw influent in the contactors. In the contactors, Zn reacts with dissolved sulfide supplied by NaHS to form insoluble zinc sulfide (ZnS) precipitate. The Cd and Pb present in the feed water are precipitated as cadmium sulfide (CdS) and lead sulfide (PbS). The feed rate of sulfide reagent is set by the operator to maintain the oxidation reduction potential (ORP) in a set range. Na_2CO_3 is added to the effluent of TK-

200 to neutralize the acidity generated by the precipitation reaction. The rate of Na_2CO_3 addition is automatically controlled using pH sensors.

The ZnS slurry flows out of the contactors by gravity to flocculation tank TK-203 where flocculent and Na_2CO_3 are added. Na_2CO_3 can be added to increase the pH above 6.5 standard units (S.U.), which is the minimum discharge pH criterion. The slurry then flows by gravity from the flocculation tank to clarifier TK-205 to settle out the ZnS solids. The clarifier is 16 feet in diameter with 8-foot high sidewalls.

3.1.2.3. Filtration, pH Adjustment and Discharge

The clarifier effluent flows by gravity to filter feed tank TK-501, which has a 650-gallon capacity. Na_2CO_3 can also be added to TK-501 if the clarifier overflow pH is less than 6.5 S.U. Filtration is an important final step in the process and is needed to meet the stringent discharge permit limits for Zn and Cd. The filter effluent flows to the clear well or directly to the discharge.

The four filters operate in parallel and there is no apparent means for controlling the rate through any given filter (rate of flow control valve or orifice plates). When the filters are returned to service following a backwash there may be some minor maldistribution of flow, however, this probably is not a major drawback. Granular media filters operate most effectively when their flow rate is equally distributed. Excessive flows tend to prematurely blind the upper portion of the filter media resulting in shorter filter runs and a need for more frequent backwashing. The filter effluent flows by gravity through an 8-inch diameter high-density polyethylene (HDPE) outfall pipe to one of two injection wells installed in gravel adjacent to French Gulch. The second injection well is used if the first injection well becomes plugged. The final effluent flow meter is mounted in a vertical section of piping and full pipe flow is needed for accurate flow measurement; this is achieved by a pressure sustaining valve. When the filters are not functioning properly, the WTP is put in “recycle mode” with effluent pumped back to the mine pool. Zn levels are typically approximately 1,000 micrograms per liter (µg/L) (99+ percent removed) without filtration. Other operating modes are “emergency shutdown” when FG-6C water is pumped directly to the mine pool and “offline” mode when FG-6C water overflow and discharges to surface water.

One filter is backflushed (or backwashed) at a time each day while the other three remain in service. Each filter is sequentially backflushed until all have been cleaned. The filtered effluent from the three filters in service is diverted to the one filter being backflushed. The flow rate of backflushing is the WTP flow rate at that time, but a flow-limiting valve installed on the backflush discharge line limits the flow to 42 gpm. If the WTP is running at 40 gpm, the backflush flow rate is 40 gpm.

Each filter has an area of 3.15 square feet (ft^2). At a backflush flow rate of 42 gpm, the rise rate in the media is 13.3 gpm/ ft^2 of media. Typically, the recommended backwashing rate for multimedia filters is 18 to 22 gpm/ ft^2. The lower rate available for these filters may not be cleaning the media effectively. However, the WTP operators have observed that at flows above 42 gpm the anthracite media begins washing out of the filters, so the backflush rate cannot be increased.

The backflush water discharges to the backflush tank which is sized to contain the volume from one complete wash cycle for the four filters. A small capacity, air-actuated diaphragm pump returns the content of the backflush tank to the contactors. Once the backflush tank is full, it takes considerable time for the tank level to be drawn down to allow another backwash cycle to begin. Normally, this is not a problem, unless the clarifier is upset and discharging high concentrations of suspended solids to the filters. Much more frequent backwashing would then be required, but the existing system will not allow it. Under this circumstance, the WTP would have to go into recycle mode until the clarifier operation is improved.

3.1.2.4. Residual Solids

The ZnS solids collected in the clarifier are dewatered in a filter press (EQ-200) achieving a filter cake with solids content of 35 to 50 percent weight (wt). The ZnS product is stored in one-ton plastic lined sacks before being shipped to a smelter. The process generates no residuals that must be landfilled. The process is intended to avoid Fe oxidation and precipitation since the presence of Fe in the final cake product complicates the smelter's operation.

3.2 REMEDIAL ACTION OBJECTIVES AND STANDARDS

This site does not have a Record of Decision (ROD), so it does not have formal Remedial Action Objectives (RAO) that would have been developed as part of a remedial investigation/feasibility study (RI/FS) and then incorporated into the ROD. The remedy RAO as presented in the 2002 EE/CA fact sheet is to limit the concentrations of dissolved Cd and Zn to 4.0 µg/L and 225 µg/L, respectively, in the Blue River. The concentrations are temporary water quality standards set by the Colorado Water Quality Control Commission and are also the remedy WTP discharge standards. The WTP only treats ARD from one seep (FG-6C) and it has not operated effectively over a continuous period so that its effectiveness in meeting the Blue River water quality standards cannot yet be evaluated. The Zn and Cd loading from other sources are not known, however, they could be high enough that the WTP alone cannot meet the stated objectives. Studies by the site team to determine if the RAO can be met by treatment of FG-6C alone are ongoing (FG-6C is approximately 2 percent of French Gulch flow volume).

For this review, the optimization review team assumed that updated sampling data will show that treating FG-6C groundwater has a positive effect to meet the RAO, thus the focus of this review is on improving the WTP effectiveness.

3.3 PERFORMANCE MONITORING PROGRAMS

The Discharge Monitoring Reports associated with the site's National Pollutant Discharge Elimination System (NPDES) permit address requirements for:

- Daily flow and pH measurements;
- Weekly WTP effluent sampling with analysis for Cd, Zn and total suspended solids (TSS);
- Monthly WTP effluent sampling and analysis for hardness, total dissolved solids (TDS); and
- Quarterly WTP influent sampling with analysis for TSS, TDS, hardness, Cd, Zn and pH.

In the past, the site team had conducted influent sampling and analysis monthly instead of quarterly (they switched to quarterly in January 2013). In addition, the site team collects monthly influent and effluent samples for sulfate, Cu, Fe, manganese (Mg), nickel (Ni) and Ag analyses. Samples are also collected at three surface water locations (BR1, BR2, FG-9 [see figure in Appendix A]) and analyzed for Zn and Cd monthly.

In addition to the laboratory analyses above, the WTP operators maintain testing equipment on-site to analyze influent and effluent daily for Zn, Fe and pH as indicators to provide immediate notification of operating ineffectiveness. Samples at other process points are taken periodically. Additional surface water sampling and analysis is conducted by others as part of continuing investigations of the sources of French Gulch metals loading.

3.3.1 TREATMENT PLANT OPERATION STANDARDS

The NPDES standards for discharging WTP effluent to surface water are listed in Table 3.

Table 3: Current WTP Effluent Limits

Parameter	From NPDES DMRs (30-day average)
Cd	4 µg/L
Zn	225 µg/L
Oil and Grease	10 mg/L
TSS	20 mg/L
pH	6.5 to 9.0 S.U.

When Zn and or TSS levels are above the effluent standards (or if any other parameter were above the effluent standards), the WTP is put into recycle mode for discharge to the mine.

4.0 CONCEPTUAL SITE MODEL

This optimization review focused on current ARD collection and WTP operations. Discussion of a CSM including ARD sources, transport and fate are beyond the scope of this review.

5.0 FINDINGS

The observations provided below are the interpretations of the optimization review team and are not intended to imply a deficiency in the work of the system designers, system operators, or site managers, rather they are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data not available to the original designers. Furthermore, it is likely that site conditions and general knowledge of treatment have changed over time.

5.1 GENERAL FINDINGS

5.1.1 WTP PERFORMANCE

Startup in 2008, the WTP has experienced a series of mechanical problems causing frequent and extended periods of recycling of effluent to the mine pool. ARD or partially treated ARD has been diverted back to the mine to avoid discharge of water directly from FG-6C. The primary mechanical difficulty appears to be with the operation of the filters. These pressure filters do not appear to have adequate controls or back flushing capabilities for proper upkeep of the media. Over relatively short periods of time, the media becomes cemented together and must be replaced. Backflushing water is supplied from the effluent of other filters in operation rather than from a dedicated supply pump. It is possible that inadequate backflush flow is provided during winter months when the plant flow is below 40 gpm. The filter system has been a continuous operational problem and is the primary reason for the WTP failing to meet the effluent standards. Deficiencies in the backflushing system may be a contributing factor to the filter problems.

5.1.2 WTP MAINTENANCE

The WTP building is compact and access around the equipment is severely constrained. The mixer motor for the sludge conditioning tank (TK-220) is pressed against the underside of the ceiling of the building. It will be a major problem for the operations staff to remove this mixer when service is needed. In other cases, chemical feed pumps are located in building corners behind tanks, with limited access for maintenance activities. There is no storage space in the building and spare parts and miscellaneous materials are stacked throughout the building resulting in a cluttered and inefficient work environment. The staff indicated that no additional buildings can be added on the site for storage or maintenance because of zoning issues; however, the working conditions appear to be having a significant impact on the ability of the staff to operate and maintain the building and its equipment effectively.

The process vessels and tanks are completely enclosed due to the need to contain fugitive H_2S emissions. As a result, the operators have limited information available concerning the operating conditions occurring in the basins and tanks. Tank levels are often unknown until overflows occur. There are level sensors on the tanks, but there did not appear to be adequate local indication for the operators to be aware of the conditions in the tanks and processes to monitor the operating conditions quickly.

The building is poorly insulated and seems to have inadequate ventilation. The ambient air in the building has low levels of H_2S from the process units. Although the building is equipped with monitors and the level is maintained below the long-term exposure limits to H_2S, air quality improvements should be considered for human health and to minimize equipment corrosion.

5.1.3 WTP CONTROLS

The control system is a proprietary system provided by BioteQ Environmental Technologies, Inc. (BioteQ), requiring the staff to contact BioteQ whenever any change in the system is needed. It seems that it would be more efficient to convert the control system to commercially available control software that could be serviced or modified by local control system integrators. There does not appear to be any benefit at this stage in the life of the facility in continually relying on BioteQ to make changes to the system. The proposed control change to include automated recycle to the mine would be useful to improve system operation and BioteQ's proposed costs are reasonable; however, the many months required to work with BioteQ to implement this change exemplifies the inefficiency of the current situation.

5.2 ARD COLLECTION AND RECYCLING

The system typically operates at less than 50 percent of capacity and could treat ARD from additional seeps if identified. Surface water data were not provided to determine how higher flow rates affect metal concentrations in French Gulch. Based on the limited data available it appears that Zn concentrations in FG-6C are higher during times of high flow.

The WTP cannot meet the Zn standard (225 µg/L) without filtration. At times, when filtration is not on-line and at other times, when the system is not meeting standards, discharge is diverted to the mine with no discharge limits. Without the filters operating, the WTP typically removes Zn to approximately 1 mg/L (>99 percent removal). While this removal is significant, it does not meet the stringent water quality discharge criteria established for the system. If the mine were inert, recycling the water to the mine would be effectively diluting contamination. With ARD-generating material, however, the added exposure of rock to water could generate ARD with higher concentrations and ultimately increase the Zn concentration at the compliance point.

5.3 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Table 4 provides a breakdown of the approximate annual cost estimates for operating this remedy based on total costs provided by the site team and general averaging by the optimization review team.

Table 4: Summary of Annual Operating Costs

Item	Approximate Annual Cost
Project Management and Labor	$104,000*
Maintenance/Subcontractors (repairs, parts, media replacement)	$80,000
Process and Surface Water In-house Laboratory Analysis	$4,000
Outside Laboratory Analysis	$6,000
Propane heat	$7,000
Electricity	$17,000
Telephone	$500
NaHS	$23,000
Soda Ash	$16,000
Flocculent	$2,500
Total	$156,000
Total* (including equivalent labor cost)	$260,000

5.3.1 UTILITIES

Electrical power costs are approximately $17,000 per year at an approximate rate of $0.082 per kilowatt hour (kWh) from Xcel Energy representing a demand of approximately 24 KW. Large consumers of electricity in the system include the process pumps and air compressor. Propane costs for building heat total approximately $7,000 per year (approximately 2,100 gallons at approximately $3.35 per gallon). Telephone service is approximately $500 per year. These are very low costs compared to similar WTPs. Even though the building is poorly insulated, it is kept at a low temperature so that propane use is minimized.

The site team reported problems with air compressor downtime. Air is used to operate four valves, four pumps and the filter press. The site team is considering replacing the valves and pumps with electric-powered alternatives to avoid the cost of an air dryer replacement, extend air compressor life and reduce utility costs. Valve replacements would total approximately $5,000 and pump replacements approximately $20,000. Potential power cost savings depend on pump run times but would be minimal; costs saved in compressor maintenance and replacement would likely be exceeded by maintenance on more expensive electric-powered pumps. Instead of the valve and pump replacements, the optimization review team recommends consideration of a redundant compressor.

5.3.2 LABORATORY ANALYSIS

The combined $10,000 annual analysis cost is very low in comparison with similar WTPs. The analysis conducted by the site team meets regulatory requirements and provides additional useful water quality information.

5.3.3 CHEMICAL COSTS

Total chemical costs of approximately $41,500 annually are a major component of total operating costs but they are consistent and dependent on the flow being treated as long as the WTP process remains the same.

5.3.4 LABOR

The site team reports combined operating labor and management (including reporting) requirements of approximately 40 hours per week. The operating labor requirements are quadruple what was estimated in the 2007 Pre-Final Engineering Report prepared by BioteQ/Lyntek. At a $50 per hour loaded rate, the unit labor rate is equivalent to $104,000 annually. The labor costs alone are relatively comparable to other WTPs, but when combined with the maintenance and subcontracted services costs, it is clear that the system operation problems are increasing overall operating costs.

5.3.5 MAINTENANCE/SUBCONTRACTED SERVICES

The site team reported large subcontractor expenses in 2012, including:

- Cummins and Ingersoll Rand ~ $7,700:
  - Combined for preventative maintenance for the generator and air compressor and repairs.

- Triangle Electric ~ $14,000:
  - Installed heat tape and heater for NaHS line and tank to help prevent from freezing.
  - Installed switch to enable exhaust fans to be turned off from outside of building.
  - Installed pipe, wire, breaker for roof heat tape, replaced thermostat and repaired heaters.
  - Installed additional outlets, troubleshoot chemical pump's variable frequency drive (VFD) and installation of two new VFD chemical drivers.
  - Annual Preventative Maintenance: check for loose wires and infrared scan, troubleshoot Na_2CO_3 screw feeder overload.

- Arvada Pump ~ $29,000:
  - Approximately one half from rebuilding the influent sump pumps that are in the FG-6C vault. All four pumps (two in use and two spares) have been rebuilt with stainless steel wear plates to prevent corrosion.
  - Replaced the hose in the sludge reseed pump, replaced a leaking Na_2CO_3 pump and rebuilt the leaking one.
  - Replaced the filter feed pump and rebuilt the defective one, and performed annual inspections and maintenance.

- Clearwater Cleanup ~ $7,500:
  - Vacuumed out the media from the filters, vacuumed out and cleaned the Na_2CO_3 tank (because of scaling), and cleaned out the septic tank.

- Various Parts ~ $24,500

These costs are extremely high for a WTP of this size and are similar to 2010 and 2011 costs. The high maintenance costs represent a system that has ongoing, non-routine operating problems associated with the filters, Na_2CO_3 and the overall building condition.

5.4 APPROXIMATE ENVIRONMENTAL FOOTPRINT ASSOCIATED WITH REMEDY

The following subsections describe the environmental footprint of the site remedy, considering the five core elements of green remediation defined by the EPA (www.cluin.org/greenremediation).

5.4.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

The primary contributor to the energy footprint is the electricity usage of approximately 207,000 kWh of electricity per year. XCel Energy is the electricity provider for the site, and based on a preliminary review of Xcel Energy's 2011 Annual Report, it appears that approximately 50 percent of the electricity is generated from coal, 22 percent from natural gas, 12 percent from nuclear plants, 10 percent from wind sources, 4 percent from hydroelectric plants and 2 percent from other sources (solar, biomass, oil and waste). Based on this generation mix, the electricity is also a major contributor to greenhouse gas (GHG) and other air emissions associated with WTP operation. The other largest contributor to GHG and other emissions is associated with chemical manufacturing and transportation to the site and on-site propane use (approximately 2,100 gallons per year).

The EPA Spreadsheets for Environmental Footprint Analysis (SEFA) were used to estimate the energy and air footprints. The results for key energy and air footprint metrics are summarized in Table 5.

Table 5: Summary of Energy and Air Annual Footprint Results

Green and Sustainable Remediation Parameter	Approximate Annual Value
Greenhouse Gas Emissions (carbon dioxide equivalents [CO_{2e}]	220 tons
Total Nitrogen Oxides (NOx) + Sulfur Oxides (SOx) + Particulate Matter (PM) emissions	3,800 pounds
Total Hazardous Air Pollutant (HAP) Emissions	80 pounds
Total Energy Use	3,600 MMBtus
Voluntary Renewable Energy Use	NA

Notes: CO_2e = carbon dioxide equivalents of global warming potential
MMBtus = 1,000,000 Btus

Based on the assumptions made in SEFA, approximately 15 percent of the carbon dioxide equivalents of global warming potential (CO_2e) footprint is from chemical usage, 3 percent is from on-site propane use for heat and approximately 74 percent is from electricity usage, 4 percent is for transportation of chemicals and 4 percent is for personnel and subcontractor transportation. Other contributions are negligible.

5.4.2 WATER RESOURCES

Relatively un-impacted site groundwater from well WO-01 is used for chemical batching and cleaning purposes (500 to 1,000 gpd). Water that is intercepted as part of the remedy is discharged to surface water, which would be the natural fate of the water in the absence of the remedy. Potable water is brought to the site from outside sources and kept in two 250-gallon tanks for the washroom and safety shower; very little potable water is used.

5.4.3 LAND AND ECOSYSTEMS

Operation of the remedy does not have secondary effects on local land and ecosystems.

5.4.4 MATERIALS USAGE AND WASTE DISPOSAL

The primary materials usage is the NaHS, Na_2CO_3 and flocculent. Residual solids from the WTP are sold to a smelter for recycling.

5.5 SAFETY RECORD

The site team did not report any safety concerns or incidents. However, as discussed in Section 5.1.2, the limited and cluttered space and low level H_2S emissions inside the WTP building are safety concerns noted during the site visit.

6.0 RECOMMENDATIONS

This section provides several recommendations related to remedy effectiveness, cost control and technical improvement. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and QAPPs.

Cost estimates provided in this section have levels of certainty comparable to those done for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Studies (-30 to +50 percent), and have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. A summary table of the recommendations with associated capital cost and changes in operating costs is included as Table 6.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 CONSIDER ALTERNATIVE FILTERS OR IMPROVE EXISTING SYSTEM

The existing filters are a frequent cause of WTP shut down. During the site visit, the potential benefit of retrofitting bag type filters in lieu of the existing pressure media filters was discussed. Bag filters are a simple means of providing polishing filtration and could reduce overall operator time associated with filter maintenance and could allow the WTP to operate at a much higher percentage up-time. While cost reduction is possible, the more important improvement would be to WTP effectiveness.

Many long-term operating treatment systems with flows exceeding 100 gpm use bag filters instead of granular media filters. However, the bags must be removed and replaced manually. While this is not a major issue, this labor requirement must be factored into the decision to make this change. It is recommended, therefore, that bag filters be pilot tested before a final decision is made. If bag filters are installed, adequate hose down and drain facilities should be available and a suitable lifting system for the bag filters could be considered. A brochure for an example of this type of filter (Rosedale multi-bag filters) is included in Appendix B.

A simple test of bag filter capacity can be performed to determine how frequently the bags would have to be replaced. If bag replacement was infrequent, bag filtration would be more cost-effective than the multi-media filters with their costs for backwash and associated maintenance. A pilot test using a small capacity filter could be conducted for approximately $5,000. If the pilot test indicates that adequate metals removal can be achieved with reasonable bag filter use, conversion to a four-plex bag filter system could be accomplished for approximately $30,000.

One of the major benefits of the bag filter system is that backflushing is not required. The limitations of the existing backflushing system have been described earlier in this report. With a dual bag filter system, one set of bag filters could be replaced while the other side of the filter remained in service with no interruption in plant operation. The bags would be a new, but small, volume/mass waste stream.

If the existing filters are kept in service, consideration should be given to making several improvements:

- Provide individual differential pressure monitors on each filter.
- Install a pressure indicator upstream of the existing pressure maintaining valve to be sure that valve is operating correctly.
- Consider adding orifice plates in the effluent lines from each filter for better flow distribution between the filters.
- Consider having a standby skid of four filters already charged with media that would be available for quick replacement if the inline filters become clogged and require media replacement.
- Consider adjusting the pH after rather than before the filters. This may reduce the potential for clogging the media.
- Continue the use of muriatic acid for cleaning the filter media on a routine basis.
- Install a level indicator/switch to prevent backflush from happening if TK-551 is too high.

These changes could be implemented for approximately $25,000.

Another option would be to provide a complete replacement skid of filters that could be quickly installed in place of the online filters if the media becomes completely clogged. With the current operation it takes approximately a month for a complete change media replacement operation. During that time, the plant is in “recycle to mine” mode with the treatment system in operation (minus the filters) with 99% of the zinc removed. The cost of the existing filters was approximately $16,000.00.

6.1.2 CONSIDER SODA ASH SYSTEM CHANGES

During the optimization site visit, the plant staff reported that the Na_2CO_3 system has also been a significant operations and maintenance problem. Currently the Y-strainer before the centrifugal pump is cleaned Monday, Wednesday and Friday to keep the flow of liquid at a constant pressure. Even though the Na_2CO_3 is at an 8 percent dilution and should not drop out of solution based on solubility graph information, the Y-strainer always contains un-dissolved Na_2CO_3. Calcium deposits are also building up in the Y-strainer after only approximately 4 months of cleaning the tank. The Na_2CO_3 pump seal has been replaced after only 8 months of use. The WTP staff is currently running hot water through the pump during the hot water flush. The original BioteQ programming stopped the pump during a hot water flush (this has been changed so the pump continues to run). This may help to remove any kind of deposit where the seal is sporadically leaking and could lengthen the life of the pump seal. The valve that controls the Na_2CO_3 feed rate to maintain the pH set point has to be replaced more than once a year due to a part of the valve leaking likely due to wear and tear. The Na_2CO_3 loop is flushed daily with hot water in an attempt to keep up the operation. It may help to add a VFD to the pump drive to control the flow of Na_2CO_3 into the process. The WTP staff has expressed a concern that VFD may slow the existing pump to such a low flow rate that the Na_2CO_3 may settle in the piping. Caustic soda (NaOH) may be an option to reduce the potential for pipe clogging since no solids are involved.

A caustic soda system would include a drum storage and feed system and chemical metering pumps. Caustic is normally delivered at 50 percent concentration and diluted at the site to approximately 25 percent concentration. There is limited space for a drum and feed pumps, however, several locations could be made available. If the feed tank had to be located in a tight location, incoming caustic could be transferred via pumping to the fixed feed tank. A simple plastic tank containment could be provided for the feed tank if it had to be located outside the existing containment area. The cost for such a system would be approximately $10,000.

Another minor improvement for the existing Na_2CO_3 system would be to provide a seal water system for the Na_2CO_3 pumps to get longer service life out of the pump seals. This is an inexpensive improvement and could easily be performed by WTP maintenance staff. Following the site visit, the WTP staff implemented this improvement.

6.1.3 DEVELOP PLAN FOR MEETING STANDARDS AT POINT OF COMPLIANCE

Determine whether and to what degree the treatment of the FG-6C seep is improving French Gulch water quality based on surface water sampling results. The mass balance had indicated that standards would be met at the point of compliance once the WTP was in operation. The optimization review team recommends determining:

- If the mass balance analysis is reasonable, or if it is not, then update it.
- If treating FG-6C is improving French Gulch substantially but not enough to meet standards, identify, capture and treat other sources, if possible.
- If no significant improvement in French Gulch is indicated, reevaluate FG-6C capture and operating system, and consider other alternatives.

This effort has been started by the site team.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 PROVIDE NATURAL GAS SERVICE FOR HEATING

The site team reported that natural gas service is available in the vicinity of the WTP. Natural gas heating would offer savings of approximately 80 percent compared to propane (based on $3.35/gallon propane and $0.80 per hundred cubic feet (ccf) natural gas and 1 ccf natural gas = approximately 1.1 gallons propane heating value). At the current propane usage rate, approximately $5,500 per year could be saved if natural gas was provided at the WTP. The cost to provide service to the WTP should be investigated; with long-term WTP operation likely, even an upfront cost of $25,000 with a 5-year payback period would be worthwhile.

Improving ventilation systems and weatherproofing the building (see Section 6.3.2) are not likely to reduce the heating costs because current practice has the building kept at a low indoor temperature.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 IMPROVE TANK LEVEL CONTROLS

Plant influent is discharged to the Feed Buffer Tank (TK-101) which has a 9,000-gallon capacity. This tank acts as a storage reservoir in the event of a WTP shutdown so that the influent pumps can continue to run while the problem is resolved. This tank, the filter feed tank and the backflush tank should be retrofitted with magnetic float type sight glass level indicators to allow the operators visual local indication of the tank level. This type of indicator includes a dual standpipe to isolate the stored liquid from the viewing standpipe to isolate the fouling that normally occurs in the viewing standpipe and is offered by Penberthy/Tyco Model MG; a brochure for this type of level indicator is provided in Appendix B. During the site visit, the operators noted that they were often hampered by a lack of ready knowledge of the levels in the tanks. The only way to find out the level is for staff to go to the control stations in the electrical room and look at the readings on the control screens. The installed cost per tank would be approximately $2,500 for a site level gage.

The WTP operation and maintenance (O&M) manual indicates that feed buffer tank is normally off-line and only brought into service during a shutdown. This tank could provide benefit to control surges into the WTP and even out the flow. Consideration should be given to keeping this tank in service (and changing the system programming to allow it) during routine operation for surge dampening.

6.3.2 IMPROVE BUILDING VENTILATION TO REDUCE H_2S

The building is poorly insulated and ventilated. At a minimum, the following should be considered to reduce H_2S in the building to provide a better work environment and improve electrical/mechanical system lifespans:

- The ventilation system should be modified to bring outside air into the control room and electrical room and discharge into the operations area to protect electrical gear.

- Individual in-line exhaust fans should be installed in the vent lines from each process unit currently leaking H_2S fumes to ensure a slight negative pressure in the headspace over each unit. These vent lines would then feed the existing H_2S scrubber system.

- Consider venting the NaHS storage tank to the outside. This tank is likely the major source of H_2S fumes.

- The overhead door should be insulated (implemented winter 2013) and heating in the chemical storage areas should be improved.

The costs of these improvements may vary greatly depending on the degree of improvement, but will likely be at least $50,000. While annual maintenance costs are expected to be reduced, the amount of reduction cannot be quantified. With long-term, possibly indefinite, WTP operation likely, improvements to the building are warranted and a major renovation should be considered.

6.3.3 STANDARDIZE CONTROLS, MAINTENANCE, AND PARTS

A high portion of O&M cost is for maintenance including subcontracted services and parts.

The most fruitful improvement in this category would be to convert the control system to commercially available control software that could be serviced or modified by local control system integrators and implement the proposed control change to include automated recycle to the mine to improve system operation. The site team should obtain proposals from vendors to accomplish this change.

Many process equipment and chemical feed and control components (pumps, probes, flow meters, level sensors, pressure sensors and switches and mixers) should be standardized as feasible and or have spares readily available. For example, the ORP probes are indicated to be installed in a “hot tap assembly” for insertion and removal from a full tank. Consideration should be given to providing a “hot-swappable” arrangement so that another ORP probe can be immediately available at each location for immediate change out with the actively installed probe. This allows immediate and quick replacement with no loss of signal.

Consideration should also be given to programming and engineering changes that automate the WTP to switch from “discharge” mode to “recycle to mine” mode. Operators currently have to manually change the position on two valves when the plant goes out of compliance (pH primarily) to send water from the discharge back to the feed buffer tank and to the mine. The "recycle to mine" option would allow the WTP to run while the problem is resolved instead of shutting whole process down. The Town of Breckenridge indicated that this automation change was considered in 2012 and a proposal from BioteQ was received. However, implementation was postponed until the five-year review and optimization review were completed.

6.4 Considerations for Gaining Site Close Out

The WTP operation is expected to continue indefinitely if it is determined that treating FG-6C water is effective in meeting the site RAO. If treating FG-6C (and potentially adding a similar ARD source, to be determined) is shown to have little or no effect on French Gulch and Blue River, the site team should reconsider continued long-term operation of the WTP and re-examine source control alternatives

If the WTP operation is indefinite, the site team should make significant efforts to achieve consistent, cost-effective WTP operation. The optimization review team does not have further recommendations regarding site close out.

6.5 Recommendations Related to Environmental Footprint Reduction

The above recommendations are likely footprint neutral given the level of accuracy of current footprinting methodologies. Significant footprint reductions would be associated with reducing electricity use and chemical use. A combined heat and power unit (likely rated between 50 and 100 kW) could provide electricity and heating from natural gas more efficiently and with lower emissions than grid electricity and propane or natural gas heat. However, the optimization team does believe there would be a favorable financial payback for the capital investment.

Table 6: Summary of Recommendations and Associated Costs

Recommendation	Reason	Cost Change
6.1.1 Consider Alternative Filters or Improve Existing	Effectiveness	$30,000
6.1.2 Consider Soda Ash System Changes by adding Caustic Soda Feed System	Effectiveness	$10,000
6.1.3 Develop Plan for Meeting Standards at Point of Compliance	Effectiveness	Not Quantified
6.2.1 Provide Natural Gas Service for Heating	Cost Reduction	($5,500)/year
6.3.1 Improve Tank Level Controls	Technical Improvement	$2,500 per tank
6.3.2 Improve Building Ventilation to Reduce H_2S	Technical Improvement	$50,000+
6.3.3 Standardize Controls, Maintenance, and Parts	Technical Improvement	Not Quantified

APPENDIX A

SELECT FIGURES FROM SITE DOCUMENTS

&

PROCESS FLOW DIAGRAM

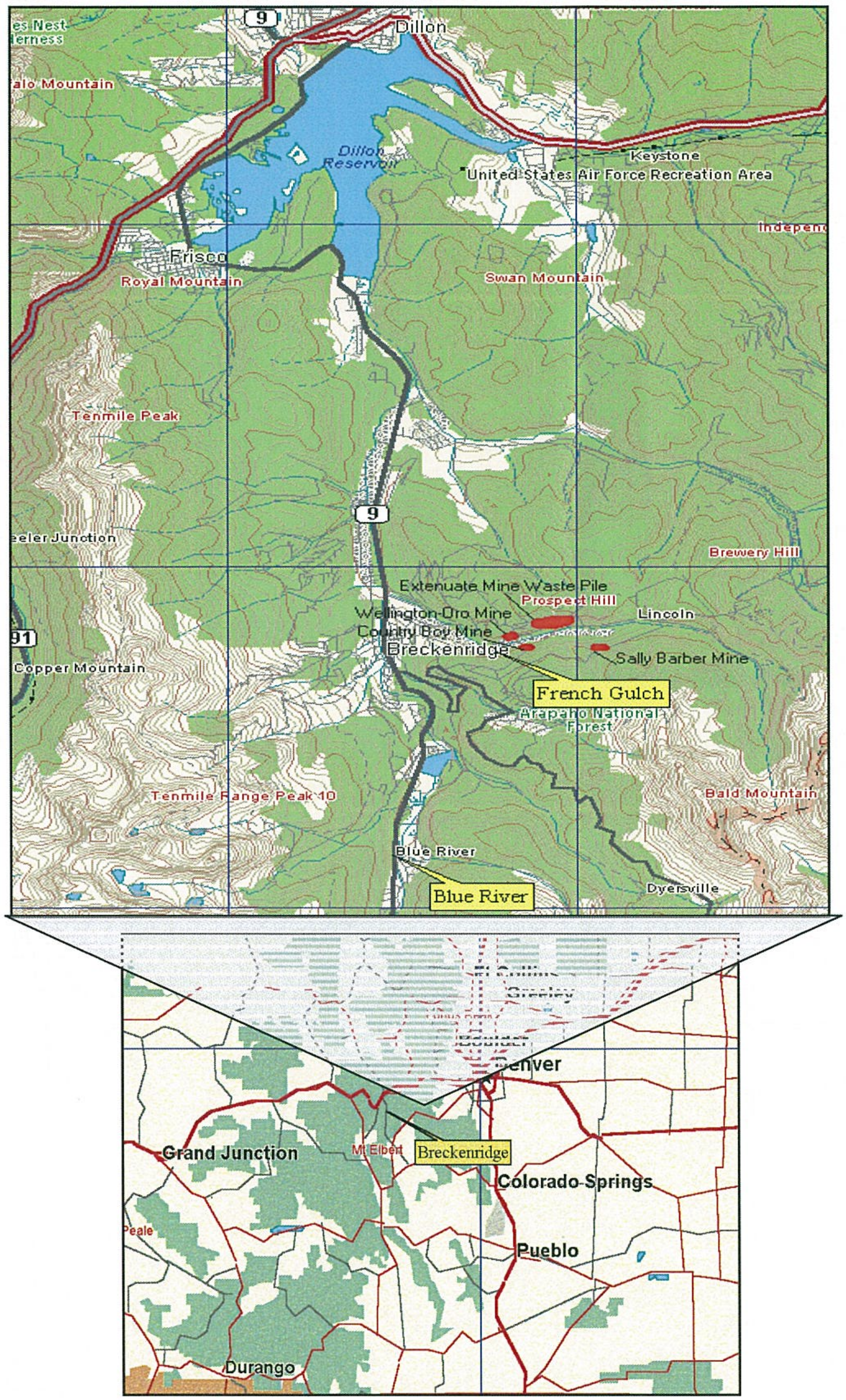


Figure 1-1
Location of the French Gulch/Wellington-Oro Mine Site

Ecological Risk Assessment for the French Gulch/Wellington-Oro Mine Site Breckenridge, Colorado

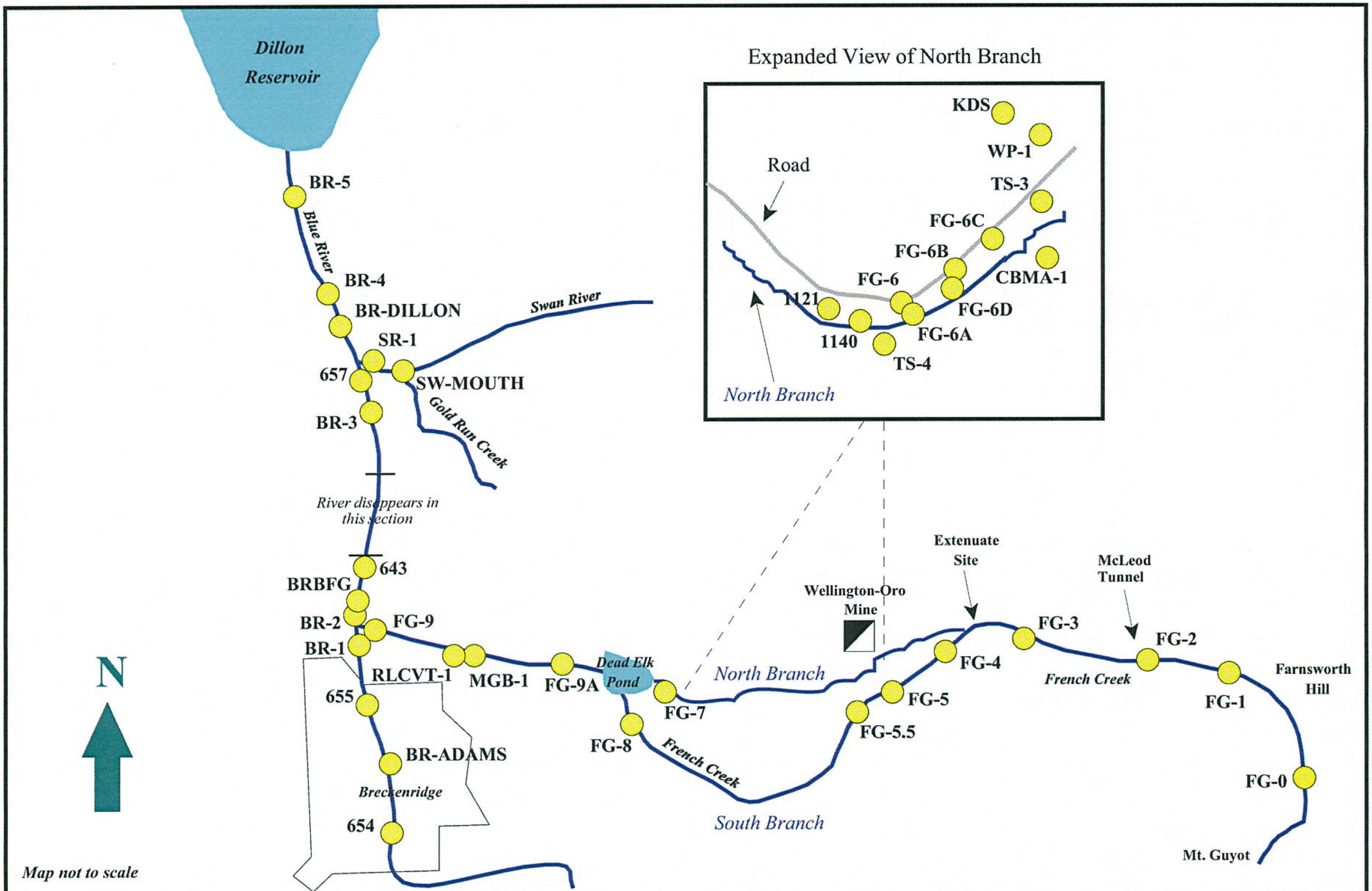
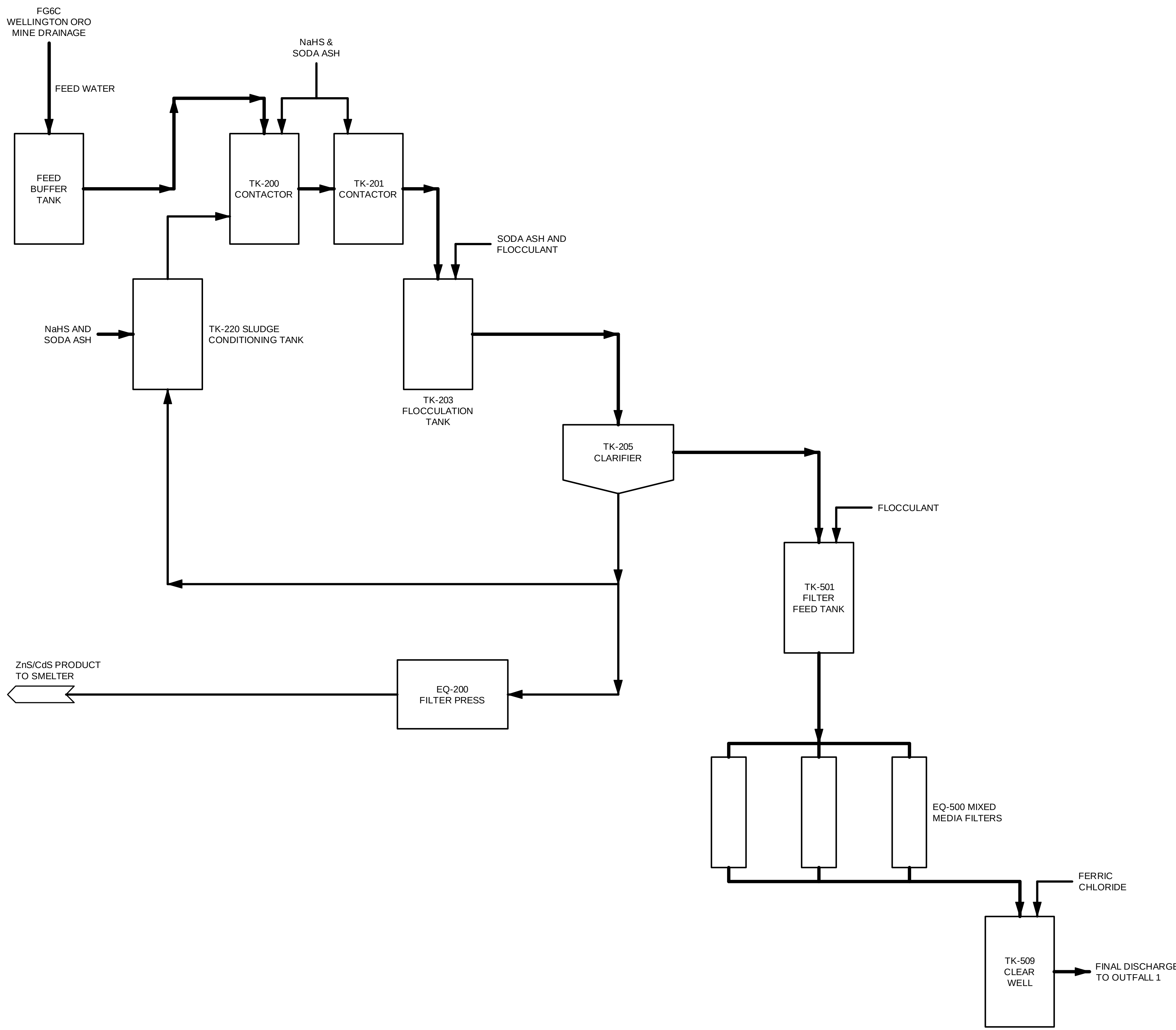


Figure 2-1
Sampling Location Map

Ecological Risk Assessment
French Gulch Wellington-Oro Mine Site,
Breckenridge, Colorado



TETRA TECH
www.tetratech.com
1576 Sherman St. Suite 100
Denver, CO 80203
Phone: (303) 825-5999 Fax: (303) 825-0642

MARK	DATE	DESCRIPTION	BY

WELLINGTON ORO MINE

PROCESS FLOW SCHEMATIC

Project No.: 133-01298-12002
Designed By: JSN
Drawn By: JLC
Checked By: JSN

PFD - 1

Bar Measures 1 inch

1/21/2013 9:28:52 AM - P:\01298\133-01298-12002\CAD\SHEETFILES\PFD 1.DWG - CLOUD, JARED

APPENDIX B

INFORMATIONAL BROCHURES:

ROSEDALE MULTI-BAG FILTERS

&

PENBERTHY MAGNETIC LIQUID LEVEL GAGES

Multi-Basket Strainers and Multi-Bag Filters

These multi-basket strainers and bag filters offer a wide range of flow capacities and contaminant-holding capabilities. They contain from 2 to 23 baskets.

To serve as a strainer, a unit is ordered with perforated stainless steel baskets (mesh-lined if desired). When ordered as a filter, it's fitted with perforated stainless steel baskets designed to hold disposable or cleanable filter bags. Industry-standard size bags are used: the standard 30 inch baskets accept bag size 2, the optional 15 inch baskets take size 1.

The standard pressure rating for all models is 150 psi. All housings can be supplied with an ASME code stamp, if required.

Features

- NSF 61 listed
- Multiple housing styles available (standard, quick access, low profile, hinged)
- Permanently piped housings are opened without tools and without disturbing the piping
- Machined cover gasket groove provides positive O-ring sealing
- Carbon steel, 304 or 316 stainless steel construction housings
- Large-area, 30 inch deep, heavy-duty, 9/64 inch perforated baskets
- Easy to clean
- Low pressure drop
- Four cover seal materials: Buna N, Ethylene Propylene, Viton®, and Teflon®
- Pressure rating 150 psi
- Flanged connections for 2 through 12 inch pipe
- Vent, drain and gage connections

Options

- ASME code stamp
- Higher pressure ratings
- Corrosion allowances
- Steam jackets

- Special connection locations
- Bag hold down assembly (standard on QII design)
- Inner baskets for dual-stage straining or filtering
- Cleanable wire mesh lined or perforated strainer baskets
- Special alloy materials
- Hydraulic cover lifting assembly
- Sanitary fittings
- Differential pressure indicators

Duplex Systems

All multi-basket models described here are also available as duplex systems. Two units come piped together with valves to permit continuous use of either unit while servicing the other. One lever actuates all valves simultaneously or it can be ordered for automatic service. See page 65.

Choose Housing Style

Designed to suit your requirements

The versatility of Rosedale Products provides a choice of several different designs.

- **Standard Housing Design (STD)** is durable and economic. It includes a davit arm and handwheel to facilitate cover removal. It is our most versatile housing design offering a variety of options, including our low profile design.

Standard Davit Arm

- **Spring Access Cover Design (HLP)** opens and closes without effort. Simply loosen the swing bolts and lift the cover up to open. An automatic cover stop is provided. See page 37 for details.

Spring Access Cover

- **Quick Access Cover (QII)** features a unique counter weight design that makes opening, closing, and change-out, fast, easy, and simple. This will significantly reduce change-out time and lower operating costs. The QAC is rated to 150 PSI and constructed to meet ASME code requirements. Built-in safety features ensure that the cover cannot be opened unless the internal pressure is first released. The QII is offered with our low profile design making bags more accessible and easy to remove.

QII Quick Access Cover

- **Low Profile Design (SLP) Housings** are compact and space saving, allowing for ease of bag change-out. Standard operating height is reduced, resulting in a safe design by eliminating platforms and ladders. The SLP is manufactured in any housing version, including our standard davit arm cover, QAC design, and spring assisted hinged cover.

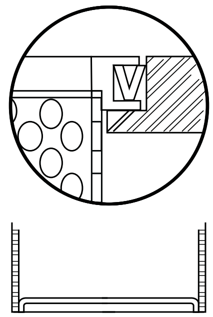
Low Profile Design

Choose Baskets That Strain or Filter

Whatever your needs dictate

Strainer baskets are cleanable, reusable.

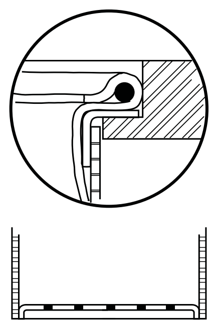
A seal is supplied on any strainer basket. It forms a seal between basket and housing to prevent dirty fluid bypass. Choose between various perforation sizes or wire mesh. Strainer baskets have flat, non-perforated bottoms and contain heavy-duty handles.



Filter bag baskets hold disposable filter bags.

Filter bags have an interference fit between the bags top rim and the housing causing a positive seal to prevent fluid bypass. Filter bag baskets have flat perforated bottoms.

Filter bags are available in a wide variety of felt, micro-fiber, monofilament and multifilament mesh materials. They are detailed completely on pages 134.



DUAL-STAGE– Dual-stage action will increase strainer or filter life and reduce servicing needs. This straining/filtering action can be achieved by ordering a second, inner basket. It is supported on the top flange of the outer basket. Both baskets can be utilized as strainers (with or without wire mesh linings), filter bag baskets, or a combination of strainer and bag basket.

Basket Data

Surface area of each 30 in. basket: 4.4 sq. ft.

Volume of each 30 in. basket: 0.6 cu. ft.

Basket Construction

For cleanable strainer baskets, choose from the following perforation diameters: 1/4, 3/16, 9/64, 3/32, or 1/16 inch (for other not shown consult factory).

Any perforated basket can also be ordered lined with wire mesh. Stainless steel wire is used in mesh sizes 20, 30, 40, 50, 60, 70, 80, 100, 150, or 200.

Filter bag baskets, have standard 9/64 inch diameter perforations that are 51% open area. A wire mesh can also be utilized with bag baskets for two advantages:

1. Fiber migration is minimized.
2. In the unlikely event of bag rupture, the wire mesh better contains the contaminant.

QII

SAFETY VALVE MECHANISM

COUNTER BALANCED COVER

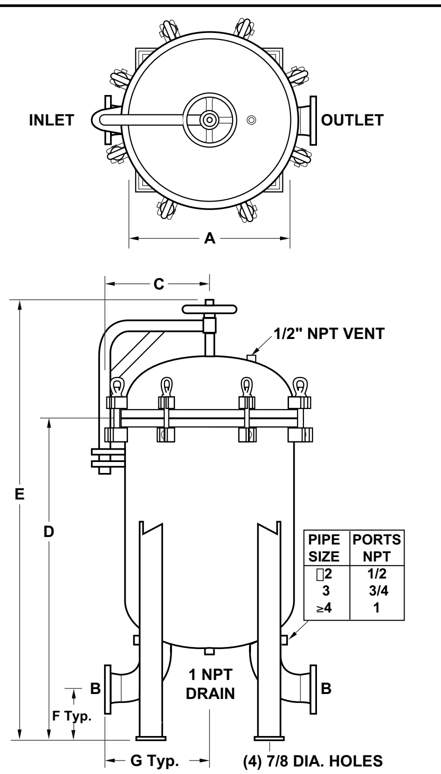
HANDWHEEL OPERATION OF TURNBUCKLE MECHANISM

ELEMENT/BAG RETAINING DEVICE

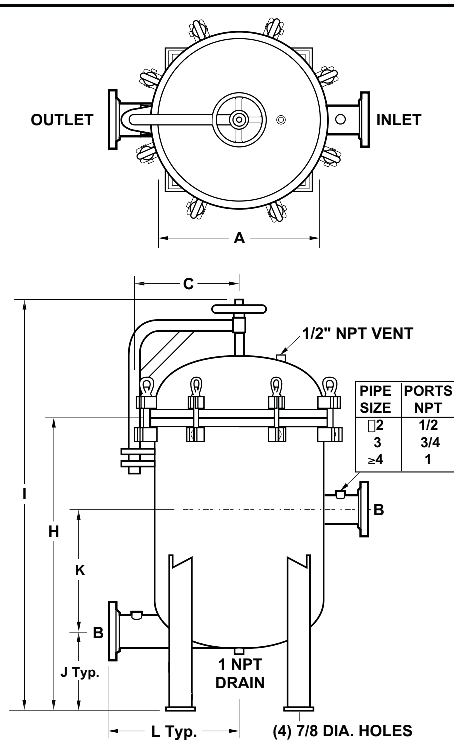
MODEL NUMBER & Dim. A	Pipe Sizes B	Leg Bolt Circle Dia.	Standard						Low Profile				
			C	D	E	F	G	Weight, lb (Approx)	H	I	J	K	L
16	2	14.0	10.9	40.1	57.1	4.50	10.5	400	37.9	54.9	8.00	15.0	13.0
	3			42.5	59.5	5.25	12.3	425	38.3	55.3	9.00	17.0	14.0
	4			44.9	61.9	6.00	14.0	450	N/A	N/A	N/A	N/A	N/A
18	2	16.0	11.9	40.5	58.0	4.50	11.1	450	39.6	58.5	8.00	15.0	14.0
	3			42.9	60.4	5.25	12.9	475	40.0	58.9	9.00	17.0	15.0
	4			45.3	62.8	6.00	14.6	500	N/A	N/A	N/A	N/A	N/A
22	2	20.0	14.0	41.4	60.0	4.50	11.9	485	39.5	58.0	8.00	15.0	16.0
	3			43.9	62.4	5.25	13.7	500	40.0	58.5	9.00	17.0	17.0
	4			46.2	64.7	6.00	15.4	515	39.5	58.0	9.00	19.0	18.0
	6			50.4	69.0	7.00	18.9	560	N/A	N/A	N/A	N/A	N/A
24	2	22.0	15.0	41.7	60.7	4.50	13.1	675	41.2	61.6	8.00	15.0	17.0
	3			44.1	63.1	5.25	14.8	700	41.6	62.0	9.00	17.0	18.0
	4			46.5	65.5	6.00	16.6	725	41.1	61.5	9.00	19.0	19.0
	6			50.7	69.7	7.00	20.1	750	N/A	N/A	N/A	N/A	N/A
30	2	28.0	18.0	42.8	63.3	4.50	15.2	635	41.3	61.9	8.00	15.0	20.5
	3			45.2	65.7	5.25	17.0	650	41.8	62.4	9.00	17.0	21.0
	4			47.6	68.1	6.00	18.7	665	41.3	61.9	9.00	19.0	22.5
	6			51.9	72.4	7.00	22.2	705	41.2	61.8	10.0	17.0	23.0
	8			56.4	76.8	8.25	25.7	850	N/A	N/A	N/A	N/A	N/A
36	3	34.0	21.0	46.4	68.4	5.25	18.8	840	43.3	64.5	9.00	17.0	24.0
	4			48.8	70.8	6.00	20.6	860	43.2	64.5	9.50	19.0	25.0
	6			53.1	75.1	7.00	24.1	870	43.2	64.4	10.5	17.0	26.0
	8			57.6	79.6	8.25	27.6	1010	43.2	64.4	11.5	17.0	27.0
	10			62.1	84.1	9.50	30.6	1150	N/A	N/A	N/A	N/A	N/A
42	4	40.0	24.0	50.0	73.5	6.00	22.6	1840	45.9	70.7	9.50	19.0	28.0
	6			54.3	77.8	7.00	26.1	1870	45.9	70.6	10.5	17.0	28.0
	8			58.8	82.3	8.25	29.6	1960	45.9	70.6	11.5	17.0	29.5
	10			63.3	86.8	9.50	32.6	2070	45.8	70.5	12.5	17.0	30.0
	12			68.0	91.5	11.0	36.1	2200	N/A	N/A	N/A	N/A	N/A
48	4	46.0	27.0	51.0	76.0	6.00	24.8	2015	46.5	71.5	9.50	19.0	32.0
	6			55.4	80.4	7.00	28.3	2075	46.4	71.4	10.5	17.0	32.0
	8			60.0	85.0	8.25	31.8	2200	46.4	71.4	11.5	17.0	32.5
	10			64.4	89.4	9.50	34.8	2350	46.4	71.4	12.5	17.0	33.0
	12			69.2	94.2	11.0	38.3	2530	N/A	N/A	N/A	N/A	N/A

Dimensions (IN)

(30-inch deep basket)



Standard



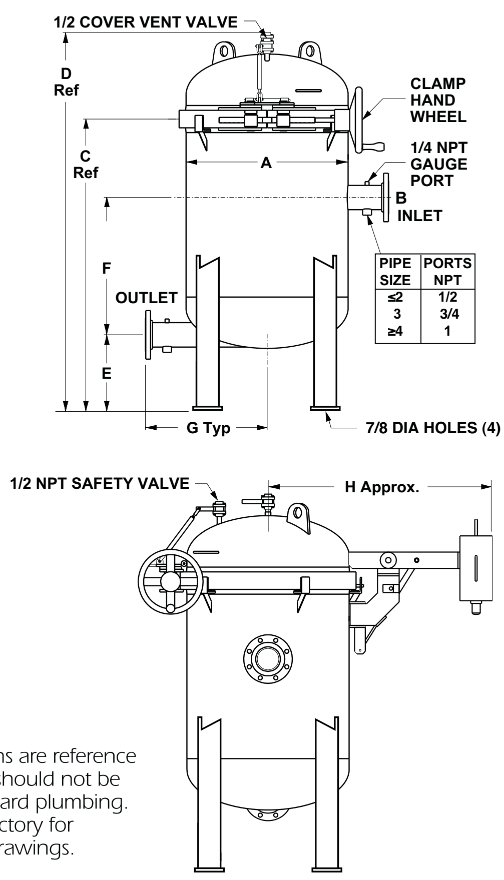
Low Profile

Dimensions are reference only and should not be used for hard plumbing. Consult factory for certified drawings.

QII Low Profile

MODEL NUMBER & Dim. A	Leg Bolt Circle Dia.	A	Pipe Size B	C	D	E	F	G	H
&	16.0	18.0	2	40.0	53.2	8.00	15.0	14.0	35.5
			3	40.4	53.6	9.00	17.0	15.0	
	22.0	24.0	2	41.5	56.2	8.00	15.0	16.0	35.5
			3	41.9	56.6	9.00	17.0	17.0	
			4	41.4	56.1	9.00	19.0	18.0	
	22.0	24.0	2	41.5	56.2	8.00	15.0	17.0	38.5
			3	41.9	56.6	9.00	17.0	18.0	
			4	41.4	56.1	9.00	19.0	19.0	
	28.0	30.0	2	43.0	59.2	8.00	15.0	20.5	41.5
			3	43.4	59.6	9.00	17.0	21.0	
			4	42.9	59.1	9.00	19.0	22.5	
			6	42.9	59.1	10.00	17.0	23.0	
	34.0	36.0	3	44.9	62.6	9.00	17.0	24.0	44.5
			4	44.9	62.6	9.50	19.0	25.0	
			6	44.9	62.6	10.5	17.0	29.5	
			8	44.9	62.6	11.5	17.0	27.0	
	40.0	42.0	4	46.4	65.6	9.5	19.0	28.0	47.5
			6	46.4	65.6	10.5	17.0	28.0	
			8	46.4	65.6	11.5	17.0	29.5	
			10	46.3	65.5	12.5	17.0	30.0	
	46.0	48.0	4	47.9	68.6	9.5	19.0	32.0	50.5
			6	47.9	68.6	10.5	17.0	32.0	
			8	47.9	68.6	11.5	17.0	32.5	
			10	47.8	68.5	12.5	17.0	33.0	

Dimensions (IN)



Dimensions are reference only and should not be used for hard plumbing. Consult factory for certified drawings.

QII **Low Profile**

Model Selection (For all housings)

Model No.	Number of Baskets	Straining, Filtering Area, ft2	Nominal Flow Rate (gpm)**	Inlet/ Outlet Size (in)
16	2	8.8	200	2,3,4*
18	3	13.2	300	2,3,4*
22	4	17.6	400	2,3,4,6*
24	6	26.4	600	2,3,4,6*
30	8	35.2	800	2,3,4,6,8*
36	12	52.8	1200	2,3,4,6,8,10*
42	17	74.8	1700	2,3,4,6,8,10,12*
48	23	101.2	2300	2,3,4,6,8,10,12*

* Not available on SLP, HLP, and QII styles.

** Nominal flow rate is based on water @ 1 psi ΔP. For optimum filtering effectiveness, a maximum fluid velocity of 10 ft/sec should be maintained.

Pressure Drop Data

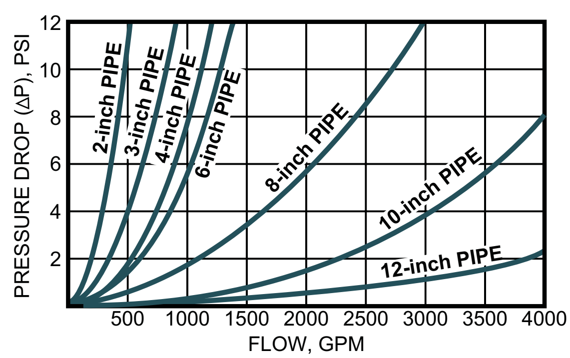
Basket strainers and bag filters are usually selected so that the pressure drop does not exceed 2 psi, when they are clean. Higher pressure drops may be tolerated when contaminant loading is low.

Determining housing pressure drop:

The pressure drops shown on the graph are reliable for all multi-basket housings, including strainer baskets or bag filter (perforated only or mesh lined). The pressure drop of any housing is governed by the size of the inlet and outlet, not the vessel itself.

1. Using the desired pipe size and approximate flow rate, determine the basic pressure drop from the graph.
2. Multiply the pressure drop obtained in step 1 by the viscosity correction factor found in the accompanying table.
3. You now have the pressure drop for a clean multi-basket unit. If bag filters are employed, you must add the pressure drop they incur to get a true pressure drop for the assembly.

Note: Filter bags are specified separately. See pages 134.



Recommended flow rates are based on housing only. Fluid viscosity, filter bag used, and expected dirt load should be considered when sizing a filter.

Viscosity Factors

CPS NUMBER									
1 (H_2O)	50	100	200	400	600	800	1000	2000	
.65	.85	1.00	1.10	1.20	1.40	1.50	1.60	1.80	

How To Order

Build an ordering code as shown in the example

Housings — Options — OPTIONAL INNER BASKET

Example: SLP-24-30-4F -1-150-C- B -S -M-20- C- 2P 1/16

HOUSING STYLE
Standard (std) = **No Symbol**
Standard Low Profile = **SLP**
Quick Access Cover = **Q**

MODEL NO.

16 = **16**	30 = **30**
18 = **18**	36 = **36**
22 = **22**	42 = **42**
24 = **24**	48 = **48**

BASKET DEPTH
15-in. = **15**
30-in. (std) = **30**

PIPE SIZE (FLANGED[1])

2-in. (Std,SLP,HLP16-48 / QII 18 & 24)	= **2F**
3-in.(Std, SLP, HLP 16-48 / QII 18 & 24)	= **3F**
4-in. (Std 16-48 / SLP, HLP 22-48 / QII 24)	= **4F**
6-in. (Std 22-48 / SLP, HLP 30-48)	= **6F**
8-in. (Std 30-48 / SLP, HLP 36-48)	= **8F**
10-in. (Std 36-48 / SLP, HLP 42 & 48)	= **10F**
12-in. (Std 42, 48)	= **12F**

OUTLET STYLE
In-line, bottom (std) = **1**
Side inlet/outlet (SLP, HLP, QII) = **2**
Side inlet/outlet, same side (SLP, HLP, QII) = **4**

PRESSURE RATING[2]
150 psi (flanged) = **150**

HOUSING MATERIAL
Carbon steel = **C**
304 stainless steel = **S**
316 stainless steel = **S316**

*** COVER SEAL**
Buna N (N/A on Q housing) = **B**
Ethylene Propylene (N/A on Q housing) = **E**
Viton® = **V**
Teflon® Encapsulated Viton® (N/A on Q housing) = **TEV**
Teflon® (solid white) (N/A on Q housing) = **TSW**

BASKET SEAL
No seal = **N**
Seal (only on strainer housings) = **S**

OPTIONAL INNER BASKET, MEDIA SIZE
Perforation diameters (for type 2P baskets)
1/4, 3/16, 9/64, 3/32, 1/16
Mesh sizes (for type 2M & 2BM baskets)
20, 30, 40, 50, 60, 70, 80, 100, 150, or 200

OPTIONAL INNER BASKET, TYPE
2B = Filter bag basket, 9/64 perforations
2P = Strainer basket, perforated metal
2BM = Filter basket, mesh lined
2M = Strainer basket, perforated, mesh lined

ASME CODE STAMP
C = Code
NSF = NSF 61 listed

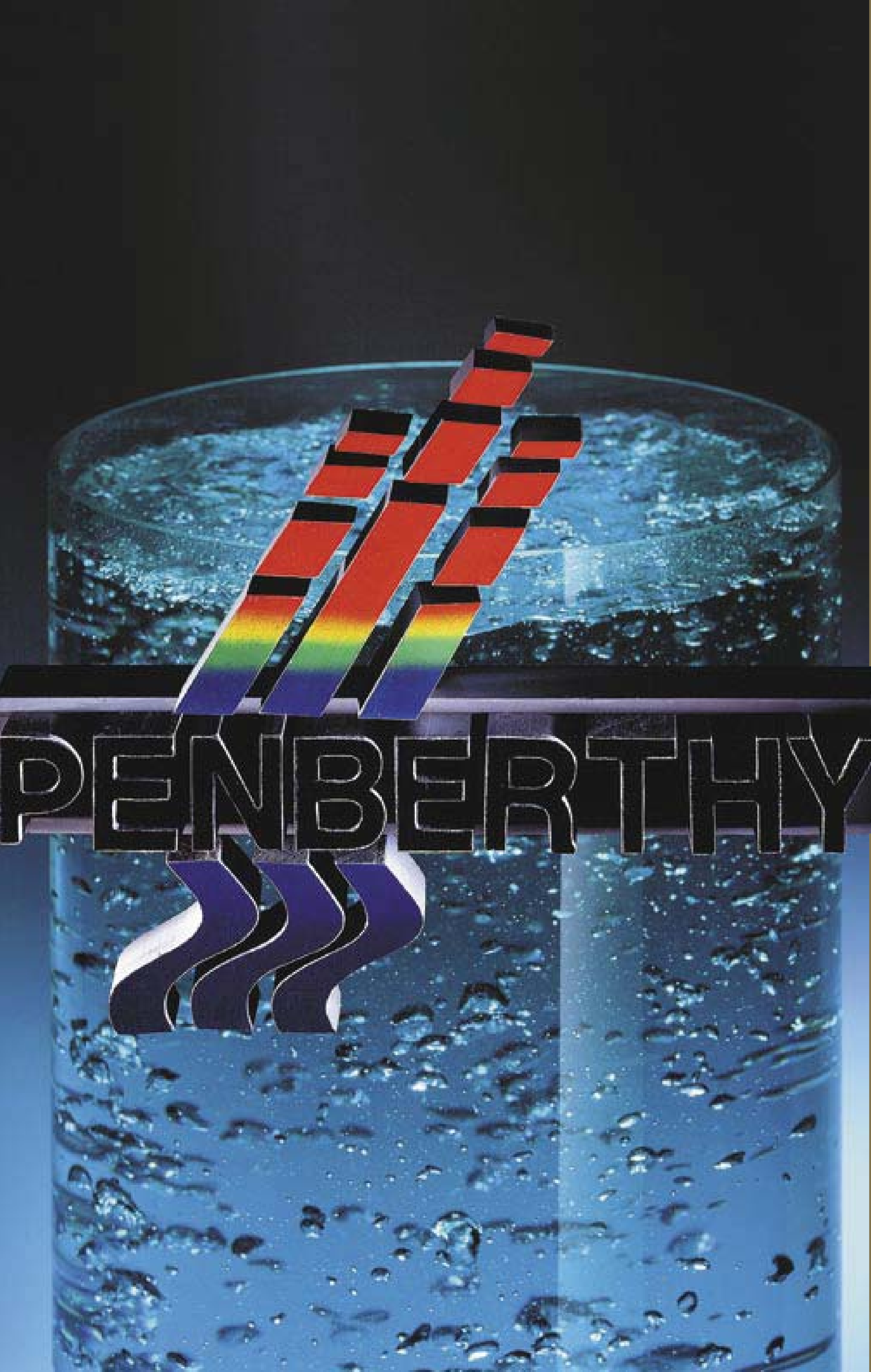
BASKET, MEDIA SIZE No symbol if type B basket was selected
Perforation diameters (for type P baskets)
1/4, 3/16, 9/64, 3/32, 1/16
Mesh sizes (for type M & BM baskets)
20, 30, 40, 50, 60, 70, 80, 100, 150, or 200

BASKET, TYPE
PB = Filter bag basket, 9/64 perforations
P = Strainer basket, perforated metal
BM = Filter bag basket, perforated, mesh lined
M = Strainer basket, perforated, mesh lined
HWM = Filter bag basket, heavy wire mesh

1. Flanges provided with the housing match the pressure rating of the vessel. Housings rated 150 psi have 150 class flanges. Housings rated 300 psi have 300 class flanges. Other styles and classes available. ANSI B16.5 Pressure-Temperature rating tables determine flange class for ASME code housings. Consult factory.

2. Higher pressure ratings available. Consult factory.

***Note: Because of its unique Quick Access Cover, the Q (QII) housing style is available only with a Viton cover seal.**



Section 4000
Bulletin 4200
Issued 10/04
Replaces 7/99

MULTIVIEW™ Magnetic Liquid Level Gages

Worldwide Leadership in Liquid Level Monitoring!

Penberthy has long been recognized as a world leader in manufacturing products for liquid level monitoring. Whether it is direct reading level gages, eductors or sight flow indicators, Penberthy is known for superior products at competitive prices. Penberthy continually strives for excellence in product quality, customer service and on-time deliveries.

It would be easy for a company that has achieved this reputation to become complacent. Not at Penberthy! With the new century in view, Penberthy has made a renewed commitment to striving for excellence, both in product quality and customer support and service. Through the course of many years of research and development, product testing both in the lab and in the field, and monitoring product performance, Penberthy has acquired a vast pool of knowledge...knowledge that has been passed on to our customers in the form of superior products.

This commitment to excellence is the core of Penberthy's business philosophy. For many years, Penberthy has recognized that the only way to truly control product quality is to "do it yourself." Therefore, all components of every product are manufactured to Penberthy's strictest specifications. Along with this single-source responsibility also comes renewed vigor in making certain that process industry needs are met in the most expedient way possible. Penberthy has a proactive business philosophy...anticipate customer needs, offer technical advice, help solve problems. That is today's Penberthy. With this vision in mind, Penberthy offers its MULTIVIEW™ Magnetic Liquid Level Gage product line to the process industry. These liquid level gages offer more versatility, greater durability, more features and more options than any other system on the market today. See why MULTIVIEW™ is the magnetic gage of choice for liquid level monitoring in today's modern processing operations.

tyco

Tyco Valves & Controls

PENBERTHY®

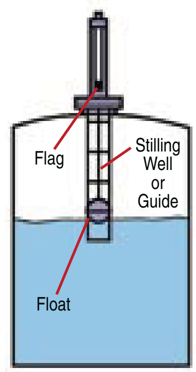
FM APPROVED

ISO 9001
Certificate Number 30053

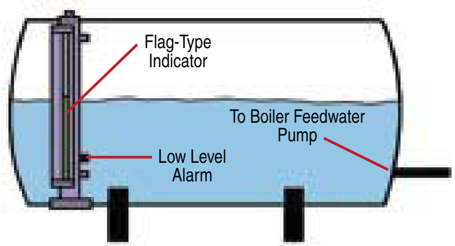
Typical Process Applications

- Sodium Hypochlorite
- Boiler Feedwater Tank
- Hydrochloric Acid
- Stop Oil
- LPG
- Interface
- Dowtherm®
- Sulfuric Acid
- Hydrogen Sulfide
- Oil/Water Separator
- Sodium Hydroxide
- Liquid Nitrogen
- Flare Drums
- Phosgene
- Ammonia
- Butane
- Seal Oil Pots
- Black Liquor
- Drip Pot
- Boiler Steam Drums
- Glycol
- Propane
- Hydraulic Oil
- Feedwater Heaters
- Extreme Flashing
- Hydrazine
- Caustic Chemicals
- Fuel Oil
- Hydrofluoric Acid
- Jet Fuel
- Molten Sulfur
- Sour Oil
- Diesel Fuel
- Deionized Water
- Sumps
- Freon
- Liquid Ethylene
- Water
- Underground Storage
- Benzene
- Asphalt Settler
- Acetic Acid
- Liquids & Slurries

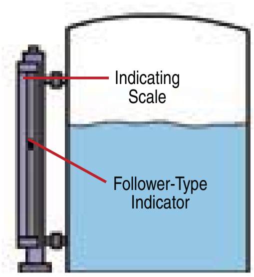
Typical Tank Configurations



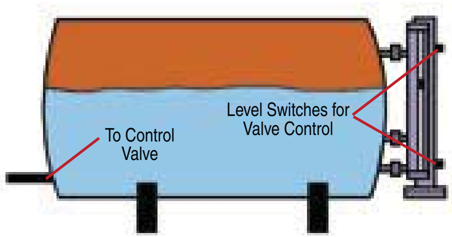
Top-Mounted Indicator



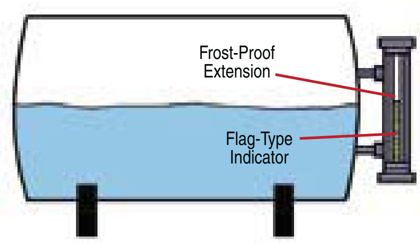
Boiler Feedwater Tank



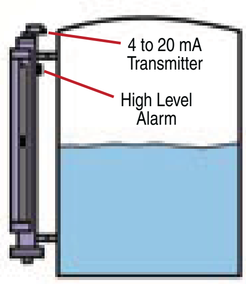
Sodium Hypochlorite



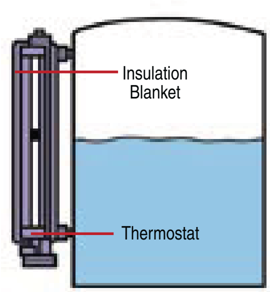
Oil/Water Separator



Liquid Nitrogen



Hydrochloric Acid



Sodium Hydroxide

Optional Transmitter

Choice of Indicators

Flag-Type

Follower-Type

Fluid Contained in Standpipe Chamber

Magnetic Float

Rugged, Versatile Options for a Wide Range of Applications

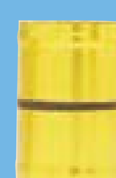
Penberthy MULTIVIEW™ Magnetic Liquid Level Gages can be built to serve practically any process industry situation. From the simplest operation to the most severe, corrosive environment, Penberthy can construct a system to best suit your company's requirements. As pioneers in magnetic gage level indication and as creators of the unique concentric magnet design, Penberthy has the expertise to know what design, specifications and options best fit any given application. Contact a Penberthy representative to discuss specific duty requirements in your operation.

Follower Temperature Test Comparison

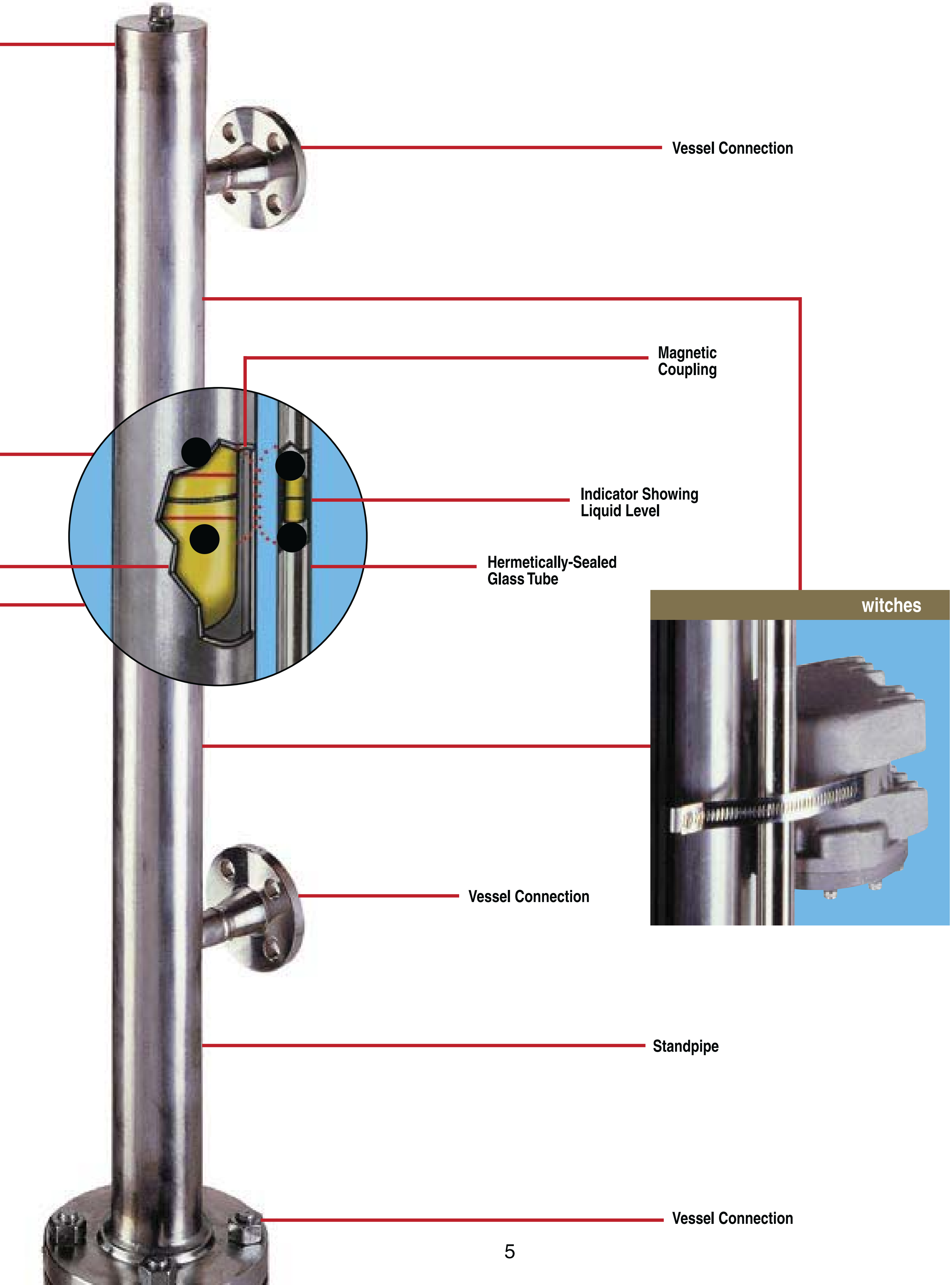
Conventional Follower


Ambient 400° F

Penberthy Anodized Gold

Ambient 800° F


Vessel Connection
Magnetic
Coupling
Indicator Showing
Liquid Level
Hermetically-Sealed
Glass Tube
Vessel Connection
Standpipe
Vessel Connection
witches

Model MG
Follower-Type

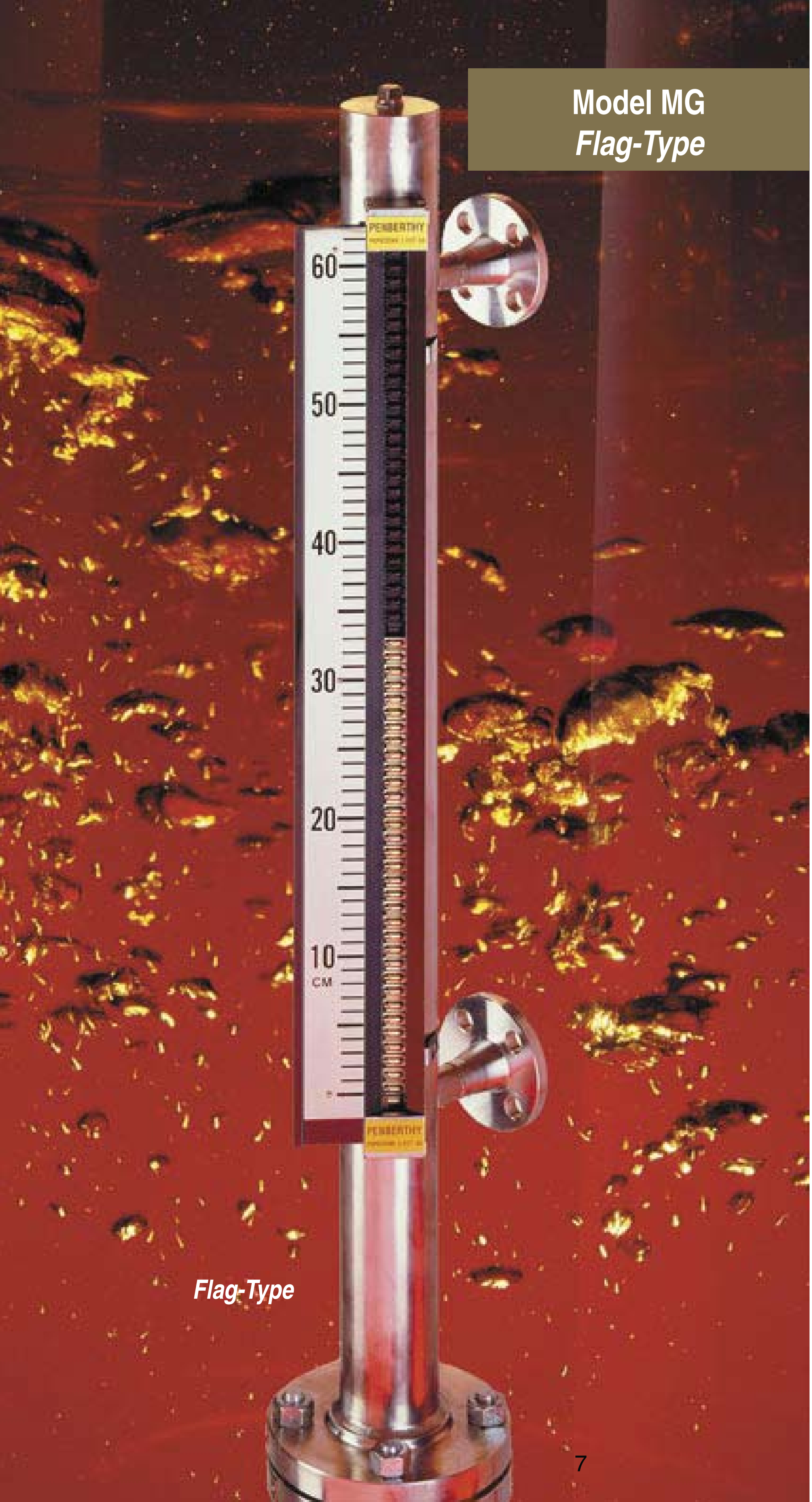
Follower-Type

MULTIVIEW™ Magnetic Liquid Level Gages utilize a standpipe constructed of 2-1/2" pipe which is connected to the process tank with either side or end connections. A float with a self-enclosed magnet is custom sized and weighted to float at the surface of the process liquid to be monitored. The float is then installed in the standpipe.

*In **MG Follower-Type** models, the unit consists of a hermetically-sealed tube in a protective view housing. Within this tube is a gold anodized aluminum follower which will mirror level changes in the process tank. This entire assembly is attached to the standpipe where the follower is magnetically coupled with the float. Because the follower and float are magnetically linked, liquid level changes in the process tank will cause both float and follower to rise and fall in unison. The result is a precise indication of the liquid level within the vessel.*

The anodized gold follower can withstand extreme heat up to 800° F without adverse wear and discoloration. Follower-type monitoring is suitable for most applications, except where violent changes in level can cause the follower to de-couple from the float. In these types of applications, flag-type indication is recommended.

Model MG
Flag-Type



Flag-Type

***MG Flag-Type** monitors provide a more secure link between indicator and float. The view housing is sealed and consists of a single column assembly of aluminum flags within an extruded aluminum channel. These flags are anodized with black on one side and gold on the other. Each flag houses a small magnet and is assembled on a single, individual axle. As the float in the standpipe rises and falls, the magnetic interaction between float and flag magnets cause the flags to rotate 180°. These changes are shown through contrasting colors – black above and gold below the liquid level.*

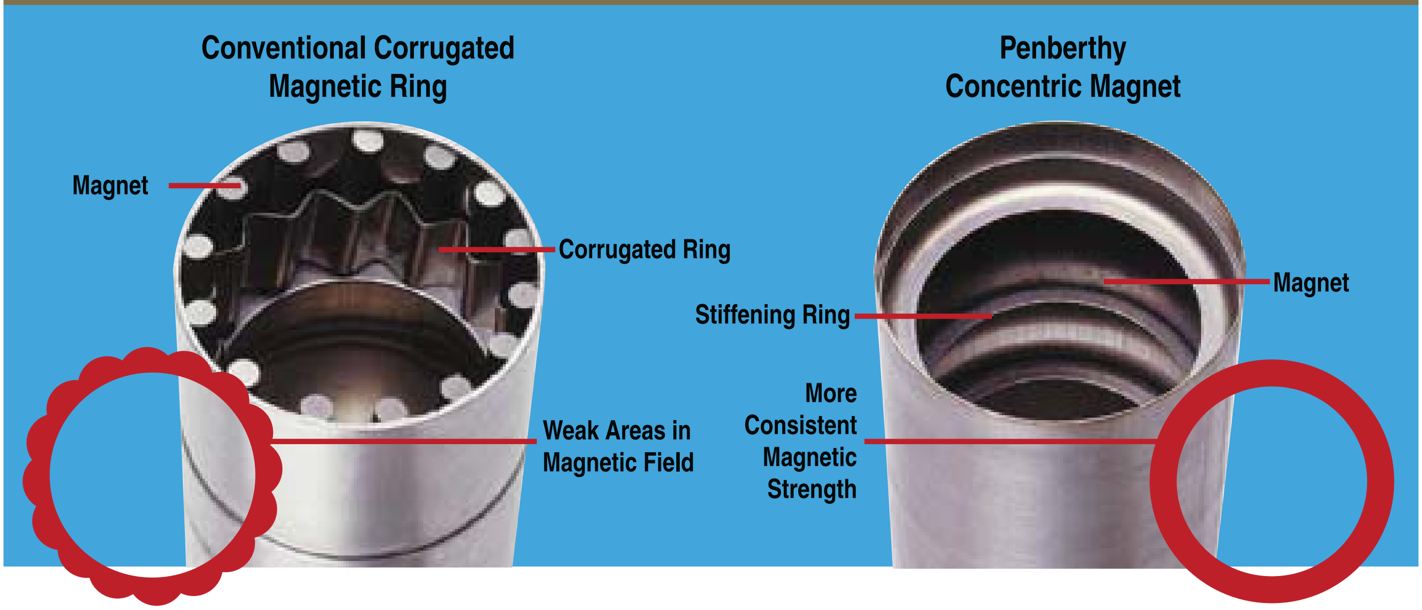
Follower-Type and Flag-Type indicators are both available with stainless steel housings.

To insure trouble-free operation, Penberthy's flags are magnetically interlocked and utilize mechanical stops. This prevents over-rotation. Penberthy's redundant axle system prevents binding, with each flag allowed to rotate on the axle and each axle free to rotate in the channel. This method of indication is always accurate, regardless of the speed of process level change or vibration.

Installation of a point-level switch can provide highly accurate, non-intrusive high/low point monitoring. For continuous level monitoring from a remote location, a level transmitter can be installed on either model as well.

For more information on switches and transmitters, see pages 14 and 15, or contact a Penberthy representative for specific details.

Magnet Design Comparison



Float Design

Conventional floats have 12 to 15 small magnets contained by a corrugated stainless steel ring as shown above. To provide internal support necessary to operate at higher pressures, a typical float contains stiffening rings throughout. It is not possible to place an effective stiffening ring within the corrugated ring design. In other words, there is no internal support in the part of the float containing the magnets. This can cause the float to collapse under higher pressure. Also, the magnetic field in the corrugated magnet design has weak areas, causing float and follower to lose magnetic contact. And, if a switch or transmitter is mounted in-line with a low point, the magnetic field may not be strong enough to actuate these devices.

The concentric magnet design of MULTIVIEW™ allows for the use of stiffening rings. This means strong internal support to prevent collapse when operating in higher pressure applications. It also allows for more consistent magnetic strength than the conventional designs.

Other float types offered in the MULTIVIEW™ product line include standard ANSI Class 150, 300, 600, 900 pressure/temperature rated floats, Super Magnet floats with > 6 times the B-H product for high vibration or other environments and Vented floats. Also available are Interface floats designed so that 50% of the float's length rides in the heavier of the two liquids; 50% in the lighter liquid. At least 0.2 difference in specific gravity is required.

Standpipe Design

Professionals in the process industry realize the importance of solid construction in their containment vessels. That applies not only to the tank, but to the level monitoring equipment as well. Level gages must be built to withstand the rigors of continuous use, often in less than ideal conditions.

Penberthy's answer to these customer demands is to design and build equipment that meets the highest construction standards. That is why all metallic MULTIVIEW™ standpipes are rated to the ANSI/ASME Boiler and Pressure Vessel Code and ANSI/ASME B31.1 and B31.3, making them perfect for use in all kinds of storage and pressure vessel applications in the most extreme duty conditions. These metallic standpipes are constructed of 2-1/2" Schedule 10 or 40 pipe and are available in a wide array of materials and/or linings (see chart on next page). Weldneck flanges, weldolets, threadolets, sockolets, 3000# threaded process couplings, and other plumbing options are offered to meet specific vessel connection requirements.

Additionally, Penberthy offers PVC and CPVC versions constructed of 2" Schedule 40 pipe for low pressure applications where cost-effectiveness and corrosion-resistance are of primary concern. These varied options make Penberthy MULTIVIEW™ products some of the most versatile on the market.

Construction Materials Available

- 304/304L STS
- 316/316L STS
- Alloy-20
- Monel
- Titanium
- Hastelloy-C
- PVC
- CPVC
- PVDF
- Tefzel® Lined
- Halar® Lined

Float Minimum Specific Gravity

Float Material	Min. Specific Gravity
316/316L STS	0.49
304/304L STS	0.49
Titanium	0.37
Monel	0.51
Alloy-20	0.47
Hastelloy-C	0.53
PVC	0.79
CPVC	0.86
Other	Consult Factory

Stated Specific Gravity is for metallic ANSI 150 Schedule 10 extended length float except for polymers.

Standard Chamber Lengths

		Overall (mm)	Vessel Centers (mm)
Side Connection	Minimum	20-7/16" (519)	4-1/4" (108)
	Maximum	258-15/16" (6577)	236" (5994)
End Connection	Minimum	20-7/16" (519)	4-1/4" (108)
	Maximum	254-15/16" (6475)	236" (5994)

Consult the factory for lengths outside of stated maximum or minimum.

Temperature Ranges

Float/Standpipe Material	Minimum Temp. °F (°C)	Maximum Temp. °F (°C)
Metallic	-325°F (-198°C)	750°F (400°C)
PVC	-20°F (-28°C)	140°F (60°C)
CPVC	-20°F (-28°C)	200°F (93°C)

Note: Specification data subject to change without notice.

Pressure Ratings (Float Limited)

Float/Standpipe Material	Standpipe Schedule 10 psig @ 100° F (kPag @38° C)	Standpipe Schedule 40 psig @ 100° F (kPag @38° C)	Float @ 100° F ANSI/psig
316/316L STS	1270 (8756)	2200 (15168)	900#/2160
304/304L STS	1270 (8756)	2200 (15168)	900#/2160
Titanium	915 (6309)	1580 (10894)	900#/1800
Monel	1400 (9653)	2430 (16754)	900#/1800
Alloy 20	1240 (8549)	2140 (15444)	900#/1800
Hastelloy -C	1480 (10204)	2560 (17651)	900#/2250
PVC	N/A	250 (1724)	150 psig
CPVC	N/A	250 (1724)	150 psig
Other		Consult Factory	

Metallic standpipe based on: $P = \frac{2\,S\,Et}{D-2yt}$ Stresses from ANSI B31.1 or ASME Section II-D

These pressure ratings assume that all fittings are equal to or exceed the standpipe ratings.

For Halar®/Tefzel® lining and other float materials, contact the factory for details.

Follower-Type with Transmitter & Switch

Flag-Type with Transmitter & Switch

Model MGVB
Vapor Bypass

Vapor Bypass

The MULTIVIEW™ Vapor Bypass Magnetic Liquid Level Gage is designed for processes where flashing may occur. Standard magnetic liquid level gages fail in these types of processes. When flashing occurs, the vapor build-up beneath the float cannot escape quickly enough due to the limited clearance between the float and the chamber wall, causing the float to rocket to the top of the chamber, where it is crushed or damaged. The Vapor Bypass variation of the Penberthy MULTIVIEW™ Magnetic Liquid Level Gage features a large chamber in combination with a unique cage system which confines the float to one side of the chamber. This allows maximum area for vapor to bypass the float and ensures proper magnetic coupling to the indicator.

No more crushed floats!
The unique guide cage design of the MULTIVIEW™ Vapor Bypass Magnetic Liquid Level Gage eliminates the risk of crushed floats due to flashing vapors.

An Effective Solution For Gauging Flashing Liquids!

Features – MGVB Vapor Bypass

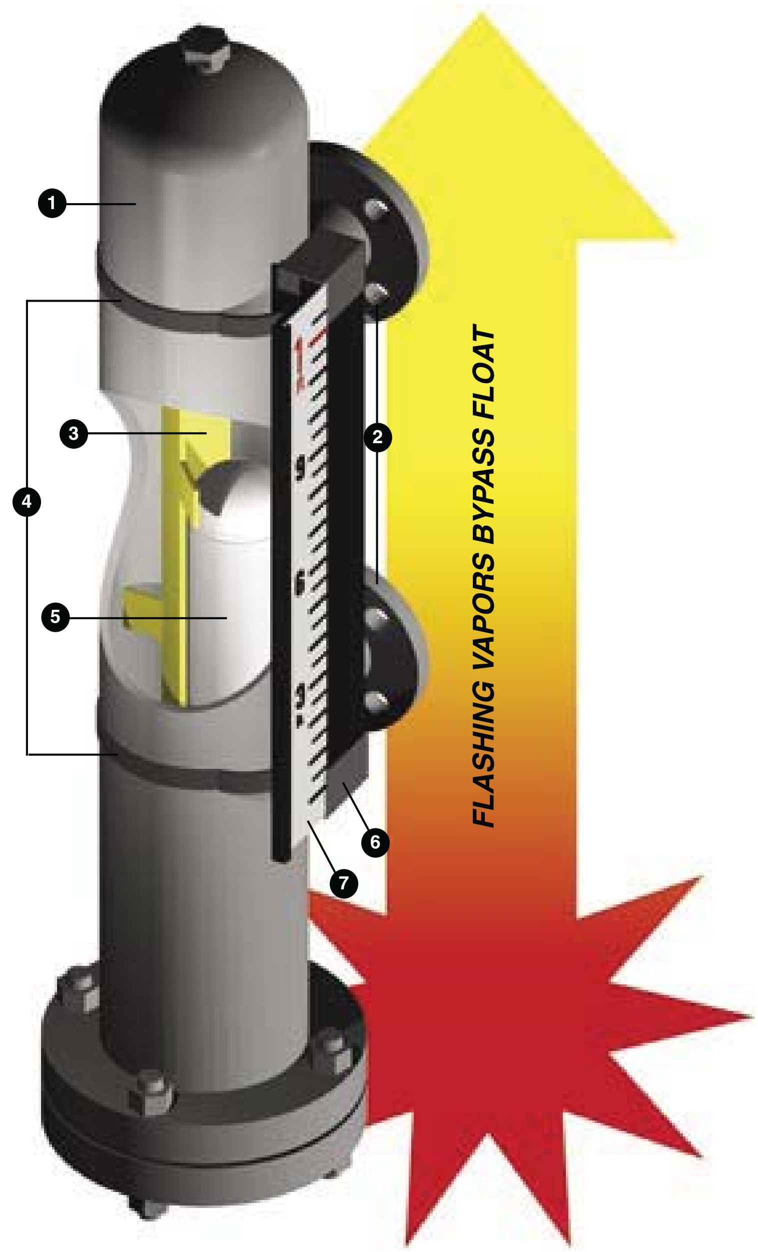
- Larger chamber and unique internal float cage
- Magnetically interlocked flag type indication
- Custom weighted magnetic float
- Designed in accordance with ASME B31.3
- Easy installation
- Virtually maintenance-free
- Optional transmitter or switches

Illustration Key	
1	Standpipe
2	Vessel Connections
3	Internal Guide Cage
4	Clamp
5	Magnetic Float
6	Flag Indicator
7	Indicator Scale

Typical Applications

This magnetic liquid level gage provides benefits when used in the following applications:

- Light Hydrocarbons
- Liquid Nitrogen
- Propane
- Methane
- Carbon Dioxide
- Anhydrous Ammonia or any pressure liquefied gas



Technical Data

- Constructed of 4" NPS Schedule 40 pipe
- Size Range: Vessel Centers: 4.25" – 236" [108 mm – 5994 mm]
- Minimum specific gravity of 0.47*
- Up to 300# ANSI rating
- Temperature range: -325°F – 750°F [-198°C – 400°C]
- Refer to previous pages in this bulletin for other features shared with the standard MULTIVIEW™.

*Based upon Titanium float

Model TMMG *Top Mount*
Model MMG *Mini Mag*

When side-mounted level monitoring is not feasible or impractical, Penberthy offers the MULTIVIEW™ ***Top Mount Magnetic Gage (TMMG)****. The TMMG features the same trouble-free method of operation as a standard MULTIVIEW™ Magnetic Liquid Level Gage.*

A stilling well is recommended for protecting against both float and tube damage... the primary cause of top mount failure. In vessels where large particulates can become trapped between float and stilling well, Penberthy's unique guide system limits the contact area, virtually eliminating the chance that particulates will clog and hinder float movement.

In applications where monitoring will operate at or near ambient temperature, the ***Mini Magnetic Gage (MMG)*** *is recommended. This system reduces initial customer cost without sacrificing performance and is perfect for applications such as air conditioning and refrigeration, filter manufacturers, waste water treatment, oil/chemical storage, skid system and tank manufacturers, and boiler feedwater tanks.*

Only flag-type level indication is offered with both the TMMG and MMG.

Features – TMMG Top Mount

The TMMG float is located in the containment vessel while the magnet assembly is at the opposite end of a tube in the standpipe. As the float level changes, so does the magnetic position. The level change is visually conveyed to the operator via the indicator mounted to the standpipe.

Options – TMMG Top Mount

- Both point level and continuous electronic level indication can be added by using Penberthy's third party approved switches and transmitters
- Optional stilling well can be installed for additional protection of both float and tube
- Unique guide system can be added to minimize the risk of particulate matter/crystalization adversely affecting float operation

Guide System

Float Minimum Specific Gravity	
Float Diameter (mm)	**Min. Specific Gravity**
3.5" (89)	0.50
4.5" (114)	0.32
6" (152)	0.21
8" (203)	0.20
10" (254)	0.15

Specific Gravities are based upon multiple ANSI 150# Titanium floats. Your actual minimum specific gravity will be application-based.

Minimum Vessel Opening Requirements	
Float Diameter (mm)	**Min. Flange Conn. Req.**
3.5" (89)	4"
4.5" (114)	5"
6" (152)	6"
8" (203)	8"
10" (254)	10"

Minimum connection sizes assume the use of a schedule 10 stilling well equal to the flange size. If a higher schedule or Penberthy's guide system is used, consult factory for sizing.

Features – MMG Mini Magnetic Gage

MMG Mini Magnetic Gages feature a nominal 1" Schedule 10 standpipe with flag-type level indication. Because of the smaller float diameter, the MMG features a conventional 6 magnet configuration with a magnetic field similar to other MULTIVIEW™ models. The MMG carries a true 150# ANSI rating. Standard material of construction for the standpipe is 316/316L STS, although 304/304L may also be specified. Float material of construction is 316/316L STS.

Options – MMG Mini Magnetic Gage

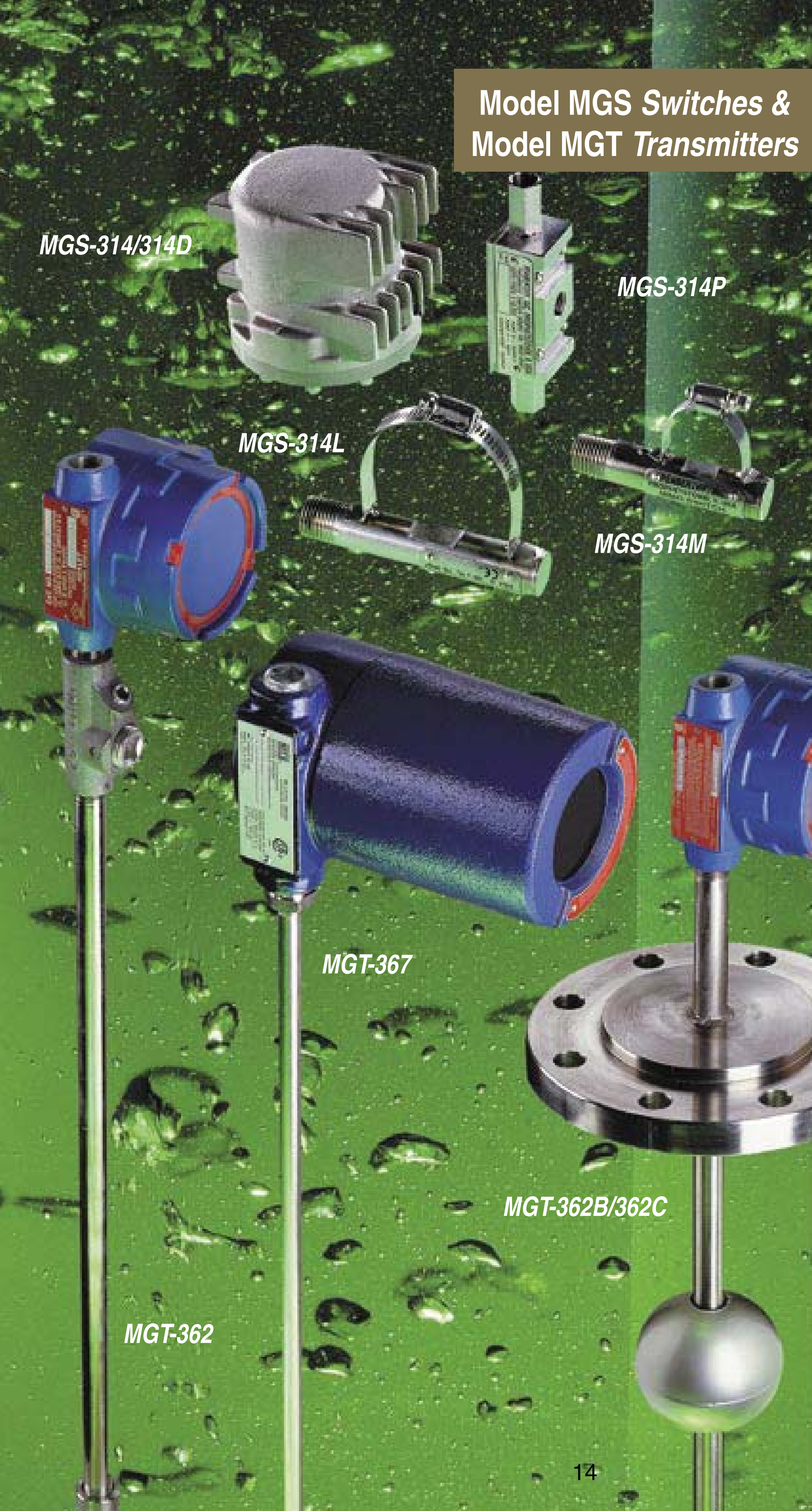
- 1 Amp Point Level Switch available for level control
- Penberthy's standard third party approved Transmitter can be added for continuous level monitoring

MMG Specifications	
Materials of Construction	Standpipe: 316/316L STS 304/304L STS Float: 316 STS
Standpipe Diameter	Nominal 1" Schedule 10
Minimum Specific Gravity	Standard Length: 0.70 Extended Length: 0.65
Maximum C-C Dimension (Indication Length)	222-5/8" * (5655 mm)
Pressure Rating	150# ANSI (PN 16/25)
Temperature Rating	Determined by chosen design of flag-type indicator

* Indication lengths greater than this require a staggered bridle arrangement. Consult factory for additional information.
Note: Specification data subject to change without notice.

Construction Materials Available – TMMG		
	Standpipe	**Float**
304/304L STS	•	
316/316L STS	•	•
Titanium	•	•
Monel	•	•
Inconel 625	•	•
Alloy-20	•	•
Hastelloy-C	•	•
Other – Consult Factory		

Model MGS *Switches* & Model MGT *Transmitters*



Both point level control and/or continuous level measurement are available with MULTIVIEW™. These options can be ordered with your magnetic gage or can be added to existing units.

***MGS Switches** provide non-intrusive point-level control and contain no mercury. They allow you to be environmentally safe without sacrificing accuracy.*

- ***MGS-314:***
  SPDT (Form C) 5A service
- ***MGS-314D:***
  DPDT (2x Form C) 10A service
- ***MGS-314L:***
  SPDT (Form C) 1A service
  Used with standard MULTIVIEW™
- ***MGS-314M:***
  SPDT (Form C) 1A service
  Used with either TMMG or MMG
- ***MGS-314P:***
  A latching pneumatic switch

***MGT Transmitters** provide continuous level indication to remote locations via 4 to 20 mA loop-powered transmitters.*

- ***MGT-362:***
  A reed switch based unit available in integral and remote mounting styles
- ***MGT-362B or C:***
  An in-tank reed switch based unit. The MGT-362B is an NPT-mounted assembly. The MGT-362C is a flange-mounted assembly. Both are available in integral or remote mounting styles.
- ***MGT-367:***
  A magnetostrictive transmitter available with HART protocol.
  MGT-367 - HART

MGS-314 Switch Specifications

	MGS-314/314D*		MGS-314L*/314M*
FM-Approved/ CSA-Certified Ex d Explosion-Proof:	Division 1,2 Class I: Groups B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #7E741-009		Division 1,2 Class I: Groups B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #7E741-009
FM-Approved/ CSA-Certified Exi a Intrinsically Safe:	Division 1, 2 Class I: Groups A,B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #7E742-009		Division 1, 2 Class I: Groups A,B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #7E742-009
Enclosures:	Watertight (Type 4) Explosion-Proof cast aluminum		Watertight (Type 4) Explosion-Proof STS
Output:	MGS-314: SPDT (Form C) 5A @ 125/250/ 277 Vac non-inductive load	MGS-314D: DPDT (2x Form C) 10A @ 125/250 Vac non-inductive load	SPDT (Form C) 1A @ 130 V ac/dc non-inductive load
Repeatability:	Better than 0.032" (0.8mm)		Better than 0.032" (0.8mm)
Response Time:	<100 milliseconds		<100 milliseconds
Deadband:	0.5" (12.7mm) of float movement		0.5" (12.7mm) of float movement
Operating Temperature:	-40°C to 185°C (-40°F to 365°F) with third party approvals -162°C to 340°C (-260°F to 645°F) without third party approvals		-40°C to 107°C (-40°F to 225°F)

*Third party approvals pending

MGS-314P Switch Specifications

Operating Medium:	Filtered Plant or Instrument Air
Enclosures:	Watertight (Type 4) STS
Operating Pressure Range:	17 to 100 psig (117 to 690 kPaG)
Air Consumption:	1.4 scfm @ 100 psig
Connections:	1/4" NPT-F
Deadband:	0.5" (12.7mm) of float movement
Operating Temperature:	-198°C to 232°C (-325°F to 450°F)

MGT-362 / 362B / 362C Transmitter Specifications

FM-Approved/ CSA-Certified Ex d Explosion-Proof:	Division 1,2 Class I: Groups B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #18F51-009
FM-Approved/ CSA-Certified Ex d Intrinsically Safe:	Division 1, 2 Class I: Groups A,B,C,D Class II: Groups E,F,G Class III: Type 4 When installed in accordance with Penberthy Drawing #18F52-009
Enclosures:	Watertight (Type 4) Explosion-Proof cast aluminum
Loop Voltage:	11 to 30 Vdc
Output:	4 to 20 mA continuous; 22 mA failure indication
Resolution:	0.375"
Response Time:	<30 milliseconds
Operating Temperature:	-40°C to 70°C (-40°F to 160°F) transmitter -162°C to 125°C (-260°F to 257°F) sensor (unprotected)

MGT-367 Transmitter Specifications

FM-Approved/ CSA-Certified Ex d Explosion-Proof:	Division 1, 2 Class I: Groups B,C,D Class II: Groups E,F,G Class III: Type 4X
Enclosures:	Watertight (Type 4X) Explosion-Proof cast aluminum
Loop Voltage:	10.5 to 36.1 Vdc
Output:	4 to 20 mA continuous
Repeatability:	0.01% F.S. or 0.015" (0.381mm)*
Hart Protocol:	Base HART Command Capability
Operating Temperature:	-34°C to 70°C (-30°F to 160°F) electronics -34°C to 149°C (-30°F to 300°F) sensor

* Whichever is greater

Note: Specification data subject to change without notice.

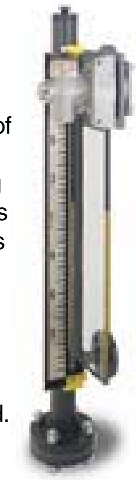
Optio

Sanitary MULTIVIEW™

To meet sanitary requirements necessary in the production of food, beverage, dairy, biomedical and pharmaceutical products and in other sanitary applications, Penberthy recommends the Sanitary MULTIVIEW™. Designed to 3A standards, this system is constructed of standard 316L SS materials with other construction materials available. Fittings and clamps meet industry sanitary regulations and allow for quick disassembly and cleaning.

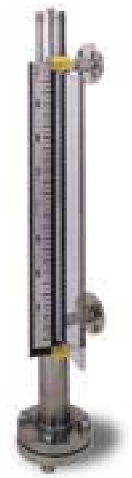
Explosion-Proof (XP) Illuminator

To improve visibility in low-light environments, an Explosion-Proof Illuminator can be a valuable addition to many level monitoring situations. This option also works well when an insulation blanket is in use. The illuminator is FM-Approved/CSA-Certified for explosion-proof usage: Class 1 Groups B, C, D, 125/250 Vac, maximum 25 or 60 watts, depending on the length required.



ısulation Blankets

enberthy Insulation Blankets can ithstand temperatures ranging om -300° F to 750° F (-184° C 400° C). Flexible blankets are vailable in thicknesses of 1/2", 1" 2". Materials available include berglass cloth coated with either TFE Teflon® or silicone rubber. igid blankets in thicknesses of ' - 12" are available in other aterials on request.

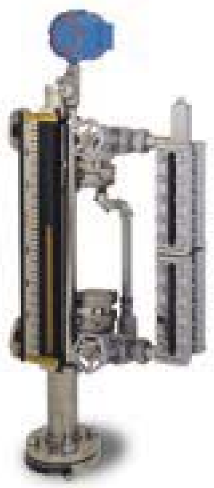


rost-Free Extensions

ı super-frigid applications such as quid nitrogen or liquefied ethylene, rost-Free Extensions should be tilized. Both types of monitoring ystems can be equipped with MMA frost-free features. This w-coefficient thermal transmitting aterial resists frost buildup to aintain clear visibility. With idths ranging from 2" to 12", ese extensions can be paired ith virtually any thickness of ısulation blanket.

Thermal Tracing

MULTIVIEW™ Magnetic Liquid Level Meters can be equipped with electrical heat tracing or piped for either refrigerant use or steam use. To determine the temperature differential, subtract the minimum expected ambient temperature from the desired maintenance temperature. An insulation blanket is highly recommended in cases such as these.



Drum Level Indicator

Combining MULTIVIEW™ monitoring with an integrally-mounted armored gage, Penberthy's Drum Level Indicator offers improved safety, convenience and versatility, meeting ASME Boiler Code, Section 1, PG-60 requirements for Water Level Indicators.
By adding the MGS-314 switch and MGT-362 transmitter, remote level measurement transmission and precise control capability is possible.

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