Process Safety Management of Highly Hazardous & Explosive Chemicals

Mechanical Integrity
What Does it Actually Mean?

Remember…

Maintain System Integrity
Protect the People

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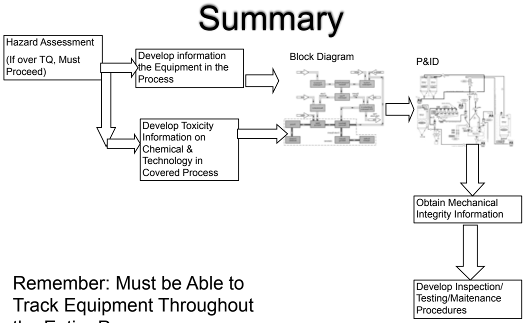
The Mechanical Integrity Process Summary



Remember: Must be Able to Track Equipment Throughout the Entire Program

Why Mechanical Integrity?

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Why Follow Mechanical Integrity Requirements:

Current OSHA NEP Inspection Results - Citations Issues

- 100 Citations - Operating Procedures
- ***94 Citations - Mechanical Integrity***
- 86 Citations - Process Safety Information
- 40 Citations - Management of Change

Bhopal gas leak (India), 1984

6

Bhopal gas leak (India), 1984

The Bhopal disaster is considered **the worst disaster** in modern history.

On the night of December 2, 1984, at the **Union Carbide Pesticide Plant** in Bhopal, water entered a tank containing 42 tons of methyl isocyanate (MIC) causing a **leak of gas** and other chemicals.

MIC is an hazardous chemical element, highly reactive, in particular with water.

A **gas cloud** was formed, and since it was denser than the surrounding air. It stayed close to the ground, causing the injuries of hundreds of thousands of people.

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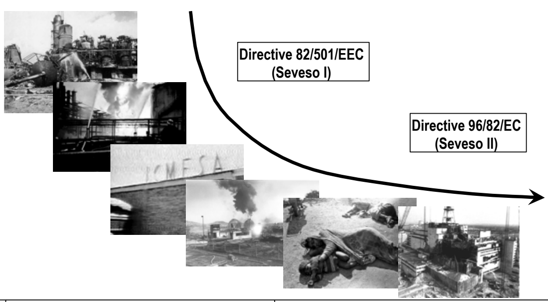
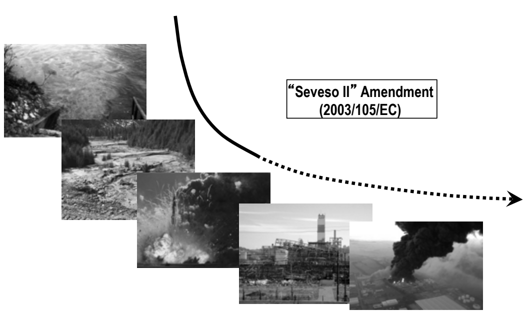
World Wide Accidents



Flixborough (UK) Giugno 1974	Beek (NL) Novembre 1975	Seveso (I) Luglio 1976	Mexico City (MEX) Novembre 1984	Bhopal (India) Dicembre 1984	Chernobyl (UA) April 1986

World Wide Accidents



Basel (CH) Novembre 1986	Baia Mare (RO) Gennaio 2000	Enschede (NL) Maggio 2000	Toulouse (F) Settembre 2001	Buncefield (UK) Dicembre 2005	BP oil spill (Mexico) 2010

Mechanical Integrity

1910.119(j)

Application. Paragraphs (j)(2) through (j)(6) of this section apply to the following process equipment:

Pressure vessels and storage tanks, Piping systems (including piping components such as valves), Relief and vent systems and devices, Emergency shutdown systems, Controls (including monitoring devices and sensors, alarms, and interlocks) and pumps

Mechanical Integrity

1910.119(j)

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Written procedures. The employer shall establish and implement written procedures to maintain the on-going integrity of process equipment.

Mechanical Integrity

1910.119(j)

Inspections: Inspections and tests shall be performed on process equipment. Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

Quality Assurance: In the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used. Appropriate checks and inspections shall be performed to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions.

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Mechanical Integrity

Equipment information should be obtained including the following:

- Piping system components include any mechanical device that is installed in-line in the piping system and is exposed to PSM-covered materials inside the piping e.g., filters, strainers, flanges, gasket materials, valves of all kinds and mechanical portions of instrumentation.
- Pressure vessels that are not registered vessels and are operated at less than 15 psig should also be included in the MI program if they contain PSM-covered materials.
- Heat exchangers are either pressure vessels or components in a piping system and therefore should be part of the MI program if they cool or heat PSM-covered materials.
- Relief and vents systems and devices include all components that are used to control pressure e.g., relief valves, rupture disks, conservation vents, vent systems, vacuum breakers and flares.

Mechanical Integrity

- Controls also include mechanical systems or devices that are intended to terminate or regulate exothermic reactions, pressure transients or other types of process safety scenarios, or to mitigate the results of such a scenario , e.g., a water curtain or quench system. Controls might also include local instrumentation to help operators handle abnormal conditions. The 2004 version of ISA Standard S84.01 recognizes manual actions as valid components of safety instrumented functions (SIFs).

- Pumps include all rotating machinery containing or exposed to PSM-covered materials, e.g., pumps, compressors, fans, blowers and agitators. It would also include any non-rotating machinery, such as an eductor, that is used to move PSM-covered fluids.

Mechanical Integrity

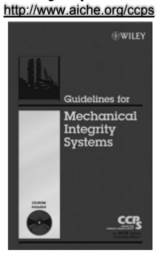
- However, you also should seriously consider adding to the MI program other equipment types that impact process safety. Examples include:
  - employee alarm systems;
  - structural and civil systems (including foundations,
  - anchor bolts, supports, pipe hangers, pipe bridges, etc.) that support the weight or movement of equipment otherwise included in the MI program;
  - key utility or service systems or components for equipment included in the PSM program, including electrical power, air, steam, nitrogen/inerting, cooling water, refrigeration/chilling, explosion suppression, quenching, etc., where the utility failure could contribute to a process safety scenario or prevent properly a covered process release scenario.

Mechanical Integrity

- It's not just the OSHA Standard -There's More
- **OSHA Compliance Directive on PSM - Clarifies how OSHA will apply the law**
- **Over 275 OSHA Letters of Interpretation - These are letters that OSHA issues to clarify how the standard will apply based on questions they receive**
- **Incorporated by reference standards in 1910.6 including ANSI, ASTM, CGA, NFPA and other codes specifically stated in the standard**
- **Governing Codes - More up to date codes with more requirements thatn just the incorporated be reference standards above including: ANSI, ASTM, CGA, NFPA, AISC and many others**
- **Recognized And Generally Accepted Good Engineering Practice" (RAGAGEP)**
- **Best practices such as Center for Chemical Process Safety (CCPS)**
- **The Employer has developed the MI program to comply with all of these.**

Mechanical Integrity & The Center for Chemical Process Safety (CCPS)

http://www.aiche.org/ccps



Center for Chemical Process Safety (CCPS)

- AIChE established the Center for Chemical Process Safety in 1985 to Focus on Engineering and Management Practices That Help Prevent and Mitigate Catastrophic Process Safety Accidents.

Video: Oklahoma Refinery Fire 2012

Mechanical Integrity & CCPS

The Primary Process Steps

- Selecting Equipment Covered
- Inspection & Testing
- MI Specific Training
- MI Procedure Development
- Quality Assurance
- Equipment Deficiency Management
- Equipment Specific Integrity Programs
- MI Program Development
- Risk Management Tools
- Continuous Improvement of MI Program

Mechanical Integrity & CCPS

CCPS contains provisions for enhanced MI control systems

New equipment design, fabrication and installation - During this phase, activities focus on ensuring that new equipment is suitable for its intended service; therefore, many of the activities in this phase are directly related to the QA activities for the early part of the equipment life cycle

Inspection and testing - During this phase, activities focus on ensuring the ongoing integrity of equipment or functionality of equipment safeguards for a specified inspection and testing interval

Preventative Maintenance - During this phase, activities focus on preventing premature failure of the equipment and its components, and can include performing servicing tasks (e.g.,lubrication) and/or inspecting and replacing components that are subject to wear

Repair - During this phase, activities focus on responding to equipment failures, and repairing and returning equipment to service in a condition suitable for its intended use

MI – The Process You Should Expect to See

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The Mechanical Integrity Process

- In Order to Maintain System Integrity, We Must Assemble:
- Block Flow Diagrams
- P&ID's
- Mechanical Integrity Information
- Quality Assurance Information

Let's Review The Process...

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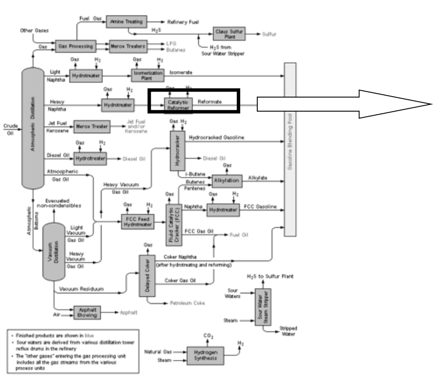
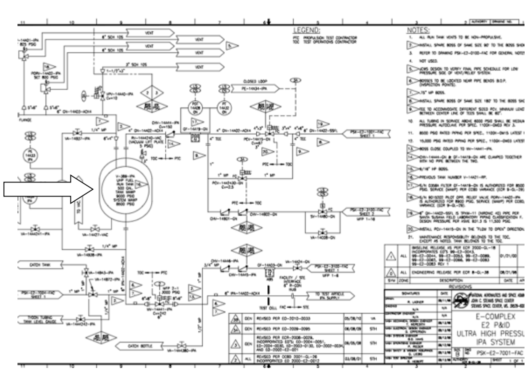
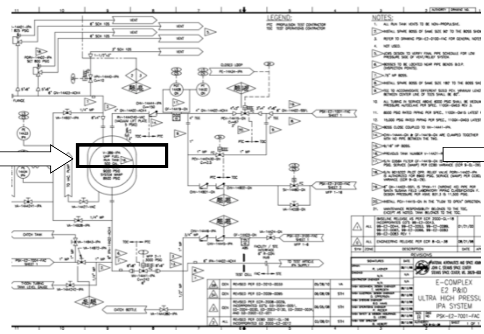
Remember - Block Diagram



Piping & Instrumentation Diagram - P&ID



Piping & Instrumentation Diagram - P&ID



Identify Each Component on the P&ID… Then…

Mechanical Integrity

- Mechanical Integrity information
  - Must be Obtained for Each Component of the Process
  - Must be Marked with Location Numbering System that Follows Form
  - Tracked Throughout the PSM Program
  - Compliance with Good Engineering Practices is Acceptable

The American Society of Mechanical Engineers

CERTIFICATE OF AUTHORIZATION

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the Code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY: MCGRAW/KOKOSING, INC. 4701 E. OXFORD STATE ROAD MIDDLETOWN, OHIO 45044

SCOPE: FABRICATION AND ASSEMBLY OF PRESSURE PIPING AT THE ABOVE LOCATION AND FIELD SITES CONTROLLED BY THE ABOVE LOCATION

AUTHORIZED: MAY 24, 2005

EXPIRES: JUNE 10, 2008

CERTIFICATE NUMBER: 27,135

Chairman of The Boiler And Pressure Vessel Committee

Director, Accreditation and Certification

Mechanical Integrity

- Mechanical Integrity information Can Be:
  - ASME information for Vessels & Pipes
  - ASTM Specification Sheets
  - ANSI Specification Sheets
  - NFPA 70E Classified Wiring Specification Sheets

UNDERWRITERS LABORATORIES INC.

CERTIFICATE OF REGISTRATION

Winbond Electronics Corporation

No. 4, Creation Road III, Science-Based Industrial Park, Hsinchu, Taiwan

No. 9, Li-Hsin Rd., Science-Based Industrial Park, Hsinchu, Taiwan

QS-9000: 1998

QS-9000 Semiconductor Supplement:1998

"Registered to QS-9000:1998 (Based on and including ISO 9001:1994)"

The design, fabrication and test of logic integrated circuits, ChipCorder integrated circuits in wafer form and in the assembled form.

The off-site facility in Taipei City, Taiwan performs sales and marketing.

The off-site in San Jose, CA, U.S.A. performs sales, marketing and design.

The off-site facility at Li-Hsin Rd., Science-Based Industrial Park, Hsinchu, Taiwan performs internal audit and design.

UL REGISTERED FIRM

Design Codes & Mechanical Integrity

- Design Codes Drive Many Times Drive Mechanical Integrity / Inspection & Testing & Quality Assurance

Advanced MI You Might Expect to See

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Mechanical Integrity

Mechanical Integrity Information should be obtained on assets including the following:

- Piping system components including
  - Filters,
  - Strainers
  - Flanges
  - Gasket materials
  - Valves
  - Mechanical portions of instrumentation
- Pressure vessels

Mechanical Integrity

Mechanical Integrity Information should be obtained on assets including the following:

- Heat exchangers
- Relief and vents systems such as
  - Relief valves
  - Rupture disks
  - Conservation vents
  - Vent systems
  - Vacuum breakers
  - Flares.
  - Reference: ASME, API, NFPA,NBBPVI, ANSI K61,1, FM, UL and ASTM

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Mechanical Integrity

- Controls also include mechanical systems or devices that are intended to terminate or regulate the covered process
- The 2004 version of ISA Standard S84.01 recognizes manual actions as valid components of safety instrumented functions (SIFs).
- Pumps Include:
  - Pumps of All Types
  - Compressors,
  - Fans
  - Blowers
  - Agitators
  - Eductors

Mechanical Integrity

- However, you also should consider adding to the MI program other equipment types that impact process safety. Examples include:
  - Employee alarm systems
  - Structural and civil systems including
    - Foundations
    - Anchor bolts
    - Pipe hangers & bridges

Mechanical Integrity

Continuing Examples Include

- Key utility or service systems including
  - In House Electrical Power
  - Air & Steam Systems Text
  - Nitrogen/inerting Systems,
  - Cooling Water
  - Refrigeration/Chilling
  - explosion suppression
  - Electrical Systems - NFPA, IEEE 446, NFPA 111, NFPA 70

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Mechanical Integrity & CCPS

TABLE 9-11
Summary of Commonly Used NFPA Codes for Fire Protection Systems

	NFPA Code	
Fire Protection Systems	*Design and Installation Requirements*	*Inspection, Test, and Maintenance Requirements*
Fire detection and alarm systems	NFPA 72	NFPA 72
Automatic sprinkler systems	NFPA 13	NFPA 25
Water spray systems	NFPA 15	NFPA 25
Foam-water sprinkler systems	NFPA 16	—
Foam systems	NFPA 11	NFPA 25
Standpipe and hose systems	NFPA 14	NFPA 25 and 1962
Fire pumps	NFPA 20	NFPA 25
Water supply systems	NFPA 22 and 24	NFPA 25
Fire hydrants	NFPA 24	NFPA 25
Portable fire extinguishers	NFPA 10	NFPA 10
Fire doors and dampers	NFPA 80 and 90A	—
Halon systems	NFPA 12A	NFPA 12A
Carbon dioxide systems	NFPA 12	NFPA 12
Clean agent systems	NFPA 2001	NFPA 2001
Dry chemical extinguishing systems	NFPA 17	NFPA 17
Buildings and structures	NFPA 101	NFPA 101

Mechanical Integrity

- Additional Examples of Mechanical Integrity Information

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HAYWARD INDUSTRIAL PRODUCTS
INSTALLATION OPERATION & MAINTENANCE
OF TRUE UNION BALL VALVES

PLEASE READ THE FOLLOWING INFORMATION PRIOR TO INSTALLING AND USING HAYWARD VALVES, STRAINERS, FILTERS, AND OTHER ASSOCIATED PRODUCTS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY.

1. Hayward guarantees its products against defective material and workmanship only. Hayward assumes no responsibility for damage or injuries resulting from improper installation, misapplication, or abuse of any product.
2. Hayward assumes no responsibility for damage or injury resulting from chemical incompatibility between its products and the process fluids to which they are subjected. Compatibility charts provided in Hayward literature are based on ambient temperatures of 70F and are for reference only. Customer should always test to determine application suitability.
3. Consult Hayward literature to determine operating pressure and temperature limitations before installing any Hayward product. Note that the maximum recommended fluid velocity through any Hayward product is eight feet per second. Higher flow rates can result in possible damage due to the water hammer effect. Also note that maximum operating pressure is dependent upon material selection as well as operating temperature.
4. Hayward products are designed primarily for use with non-compressible liquids. They should NEVER be used or tested with compressible fluids such as compressed air or nitrogen.
5. Systems should always be depressurized and drained prior to installing or maintaining Hayward products.
6. Temperature effect on piping systems should always be considered when the systems are initially designed. Piping systems must be designed and supported to prevent excess mechanical loading on Hayward equipment due to system misalignment, weight, shock, vibration, and the effects of thermal expansion and contraction.
7. Because PVC and CPVC plastic products become brittle below 40F, Hayward recommends caution in their installation and use below this temperature.
8. Published operating torque requirements are based upon testing of new valves using clean water at 70F. Valve torque is affected by many factors including fluid chemistry, viscosity, flow rate, and temperature. These should be considered when sizing electric or pneumatic actuators.
9. Due to differential thermal expansion rates between metal and plastic, transmittal of pipe vibration, and pipe loading forces DIRECT INSTALLATION OF METAL PIPE INTO PLASTIC CONNECTIONS IS NOT RECOMMENDED. Wherever installation of plastic valves into metal piping systems is necessary, it is recommended that at least 10 pipe diameter in length of plastic pipe be installed upstream and downstream of the plastic valve to compensate for the factors mentioned above.

SOCKET CONNECTION:
Socket end connections are manufactured to ASTM D2467-94. Solvent cementing of socket end connections to pipe should be performed per ASTM specifications D2855-87. Cut pipe square. Chamfer and deburr pipe. Surfaces must be cleaned and free of dirt, moisture, oil and other foreign material. Remove assembly nuts and end connectors from valve body. Slide assembly nuts, with threads facing valve, onto pipe to which the end connector is to be cemented. Apply primer to inside socket surface of end connector. Never allow primer or cement to contact valve ball or end connector o-ring sealing surfaces, as leaking may result. Use a scrubbing motion. Repeat applications may be necessary to soften the surface of the socket. Next, liberally apply primer to the male end of the pipe to the length of the socket depth. Again apply to the socket, without delay apply cement to the pipe while the surface is still wet with primer. Next apply cement lightly, but uniformly to the inside of the socket. Apply a second coat of cement to the pipe, and assemble the end connector to the pipe, rotating the end connector 1/4 turn in one direction as it is slipped to full depth on to the pipe. The end connector should be held in position for approx. 30 seconds to allow the connection to "set". After assembly wipe off excess cement. Full set time is a minimum of 30 minutes at 60 to 100 F. Full cure time should be based on the chart below.

JOINT CURE SCHEDULE:
The cure schedules are suggested as guides. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual manufacturer's recommendations for their particular cement should be followed.

Temperature Range During Cure Period(B) °F(°C)	Test Pressures for Pipe Sizes ½" to 1-1/4": Up to 180 PSI (1240 kPa)	Above 180 to 370 PSI (1240 to 2550 kPa)	Test Pressures for Pipe Sizes 1-1/2" to 3": Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2172 kPa)	Test Pressures for Pipe Sizes 4" & 5": Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2172 kPa)	Test Pressures for Pipe Sizes 6" to 8": Up to 180 PSI (1240 kPa)	Above 180 to 315 PSI (1240 to 2172 kPa)
60 to 100 (15 to 40)	1 hour	6 hours	2 hours	12 hours	6 hours	18 hours	8 hours	1 day
40 to 60 (5 to 15)	2 hours	12 hours	4 hours	1 day	12 hours	36 hours	16 hours	4 days
20 to 40 (-7 to 5)	6 hours	36 hours	12 hours	3 days	36 hours (A)	4 days (A)	3 days (A)	9 days (A)
10 to 20 (-15 to -7)	8 hours	2 days	16 hours	4 days	3 days (A)	8 days (A)	4 days (A)	12 days (A)
Colder than 10 (-15)	Extreme care should be exercised on all joints made where pipe, fittings or cement is below 10°F.							

A: It is important to note that at temperatures colder than 20°F on sizes that exceed 3 in., test results indicate that many variables exist in the actual cure rate of the joint. The data expressed in these categories represent only estimated averages. In some cases, cure will be achieved in less time, but isolated test results indicate that even longer periods of cure may be required.
B: These cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT=in a dry fit the pipe bottoms snugly in the fitting socket without meeting interference).

THREADED CONNECTION:
Threaded end connections are manufactured to ASTM specifications D2464-88, F437-88 and ANSI B2.1. Wrap threads of pipe with Teflon tape of 3 to 3-1/2 mil thickness. The tape should be wrapped in a clockwise direction starting at the first or second full thread. Overlap each wrap by, 1/2 the width of the tape. The wrap should be applied with sufficient tension to allow the threads of a single wrapped area to show through without cutting the tape. The wrap should continue for the full effective length of the thread. Pipe sizes 2" and greater will not benefit with more than a second wrap, due to the greater thread depth. To provide a leak proof joint, the pipe should be threaded into the end connection "hand tight". Using a strap wrench only (Never use a stillson type wrench) tighten the joint an additional 1/2 to 1-1/2 turns past hand tight. Tightening beyond this point may induce excessive stress that could cause failure.

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FLANGED CONNECTION:
Flange bolts should be tight enough to slightly compress the gasket and make a good seal, without distorting or putting excessive stress on the flanges. Suitable washers should be used between the bolt head and flange and the nut and flange. Bolts should be tightened in alternating sequence.

RECOMMENDED FLANGE BOLT TORQUE

FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.	FLANGE SIZE	BOLT DIA.	TORQUE FT. LBS.
1/2	1/2	10-15	2	5/8	15-25
3/4	1/2	10-15	2-1/2	5/8	20-25
1	1/2	10-15	3	5/8	20-25
1-1/4	1/2	10-15	4	5/8	20-25
1-1/2	1/2	10-15	6	3/4	30-40

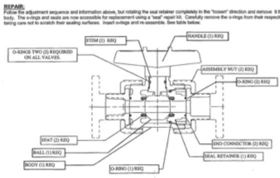
NOTE: USE WELL LUBRICATED METAL BOLTS AND NUTS. USE SOFT RUBBER GASKETS.

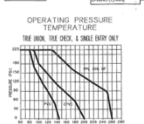
ADJUSTMENT:

EXTREME CAUTION MUST BE TAKEN WHEN WORKING ON THIS VALVE.
THE PIPING SYSTEM MUST BE DEPRESSURIZED AND DRAINED. PROPER CARE MUST BE TAKEN. CONSULT M.S.D.S. (MATERIAL SAFETY DATA SHEETS) INFORMATION REGARDING YOUR SPECIFIC APPLICATION.

Remove the assembly nut and end connector from the "adjust" end of the body, or the complete valve body from the piping system. The front face of the seal retainer indicates which direction of rotation tightens or loosens the seal retainer, with the word "tighten" and a directional arrow, and the word "loosen" and a directional arrow. Direction of rotation may vary depending on date of manufacture. The Assembly nut should be installed on the valve "hand tight". Using a strap wrench only the joint may be tightened 1/2 to 3/4 of a turn past hand tight.

REPAIR:
Follow the adjustment sequence and information above, but rotating the seal retainer completely in the "loosen" direction and remove it from valve body. The o-rings and seals are now accessible for replacement using a "seal" repair kit. Carefully remove the o-rings from their respective locations taking care not to scratch their sealing surfaces. Insert o-rings and re-assemble. See table below.





Recommended valve stem torque to rotate the ball 360° when valve is reassembled.

VALVE SIZE	TORQUE IN*LB
1/2"	40
3/4"	50
1"	60
1 1/2"	70
2"	80
3" & 2 1/2"	140
4" & 6"	170

TUIS REV D
June 19, 2001
ECR 9688
File: 08H7.DOC

38

Georg Fisher Type 360 Ball Check Valve – Engineering Specification

1.0 Summary
The product specified in this document is for Type 360 Ball Check Valve from Georg Fischer.

2.0 Specification and Certifications
The valve is to meet ASTM standards for PVC and CPVC materials. Polypropylene and PVDF versions shall be FDA CFR 21 177.1520 and USP 25 Class VI (physiological non-toxic) compliant. Polypropylene 360 valves will be in accordance with EN ISO 15494 specification. PVDF 360 valves will be in accordance with ISO 10931 specification.

2.1 Pressure/Temperature
The 360 Ball Check valves are rated for:
- 232 PSI for PVC and CPVC socket at 72°F
- 150 PSI for PVC and CPVC threaded at 72°F
- 150 PSI for PP at 72°F
- 232 PSI for PVDF fusion at 72°F
- 150 PSI for PVDF threaded at 72°F

2.2 Materials
The 360 valve body shall be constructed of PVC, CPVC, Polypropylene, or PVDF. Seals shall be made of FPM or EPDM.

2.3 Function
Ball check valves 3/8" through 2" shall be of true union design. Body interior shall have molded ribs to serve as a cage and ball guide to assure proper seating. Valve may be equipped with a screen to create a foot valve. Seat carrier shall have left-hand threads to prevent possible unscrewing when threaded end connector is installed on the pipe.

4.0 Approved Manufacturer
Approved manufacturer is Georg Fischer with no equal.

ProSeries® CHEM-FEED® Engineered Skid Systems

by Blue-White Ind. | Engineering and Technical Data

CHEM-FEED® CFS

- Single pump and dual pump systems
- Strong, lightweight polyester powder coated welded aluminum structure
- Efficient, small footprint design
- Flow indicator
- Drip containment tray
- Stainless Steel mounting pads
- Can be shipped via UPS

Dual pump model number CFS-2AA-AAAAAA Shown with Flex-Pro pump sold separately

Single pump model number CFS-1AA-AAAAAA Shown with Chem-Pro pump sold separately

Complete the system by ordering any of the following ***ProSeries****® metering pumps:*

- **Flex-Pro® A3 or A4 series Peristaltic Metering Pump with Integral Controller**
- **Chem-Pro® C2 or C3 series Diaphragm Metering Pump with Integral Controller**

Applications:

- Chemical metering
- Chlorination
- Flouridation
- Potassium Permanganate
- Alum
- Sodium Bisulfite / Bisulfate
- Hydrochloric Acid
- Polymers
- Caustics
- Flocculants

Chem-Feed Skid System Features:

Chem-Feed Engineered Skid Systems were designed and engineered using solid modeling tools for superior piping installation and easy component maintenance. Custom engineered universal mounting blocks and pre-machined mounting slots provide for easy component servicing and replacement. Lightweight for wall of floor mounting. Each factory built and tested system includes the following standard components:

Pressure Relief Valve - Protects the system from over-pressurization, 5-100 psi setting range, 150 psi maximum system pressure.

Check Valve - Protects the user from back-flow during pump maintenance.

Flow Indicator - Provides a visual indication of chemical movement through the system.

The following optional components are available for specification (see the ordering matrix):

Inlet Y Strainer - Recommended for Diaphragm Pump systems.

Calibration Cylinder - Confirm pump output under system conditions. Specify cylinder volumes from 1.8 GPH to 32 GPH.

Pulsation Dampener - Protect the system components from pulsation. Recommended for diaphragm pump systems.

Pressure Gauge with Guard - Isolate and protect the system pressure gauge. Specify pressure ranges from 0-30 psi, 0-100psi, or 0-200 psi.

Flow Verification Sensor - Provides an electronic pulse to the pump to verify chemical movement through the system (minimum flow capability one ounce per minute).

Blue-White Industries, Ltd

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John C. ERNST Co.

Sight Flow Indicators

- Model No. Index
- ✓Sight Flow Indicators
- Flow Meters & Totalizers
- Liquid Level Gauges & Valves
- Glass & Gaskets
- Sight Windows
- Switches Flow & Level
- Ejectors & Eductors
- Terms & Conditions
- Home

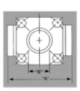
High Pressure - Double Window - Threaded

Model 110SM

Model	Carbon Steel
110	Plain
112	Flapper
113	Drip Tube

Model	316 Stainlesssteel
150	Plain
152	Flapper
153	Drip Tube

Add pressure suffix to Model Number. Example: For 600 psi unit, Model 150SM. Rotator not available



Unit Size	Dimensions in Inches & (cm) A	B	Wt lbs
1/4 3/8	3-3/4 (9.5)	3/4 (1.9)	6
1/2 3/4	4-1/2 (11.4)	1 (2.5)	8
1	4-7/8 (12.4)	1 (2.5)	9
1-1/4 1-1/2	6 (15.2)	1-1/2 (3.8)	15
2	7-1/4 (18.4)	2 (5.1)	35

Features

- **Sizes 1/4" to 2" NPT**
- **Bolted Covers**

Ratings

- SM: 600 psi @ 300°F
- SH: 1000 psi @ 300°F
- SX: 2000 psi @ 300°F
- XX: 3000 psi @ 300°F

Materials (Wetted)

- Glass: Temp Borosilicate
- Seals: Vary with Pressure
- Flapper/Drip Tube: 316SSS

High Pressure - Double Window - Flanged

Model 210SM

Model	Carbon Steel
210	Plain
211	Rotator
212	Flapper
213	Drip Tube

Model	316 Stainless
250	Plain
251	Rotator
252	Flapper
253	Drip Tube

For 300lb unit add SM to Model.
For 600lb unit add SH to Model.
Example: 210SM

Features

- **Sizes 1/2" to 8" Flanged**
- **300lb & 600lb ANSI**

Ratings*

- **300 lb ANSI Carbon Steel**
  740 psi @ 100°F
  600 psi @ 500°F
- **300 lb ANSI 316 Stainless**
  720 psi @ 100°F
  480 psi @ 500°F
- **600 lb ANSI Carbon Steel**
  1480 psi @ 100°F
  1200 psi @ 500°F
- **600 lb ANSI 316 Stainless**
  1440 psi @ 100°F
  995 psi @ 500°F

Materials (Wetted)

- Glass: Temp Borosilicate
- Seals: Neoprene,

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HAYNES International CORROSION-RESISTANT ALLOYS

FABRICATION OF HASTELLOY® CORROSION-RESISTANT ALLOYS

General Guidelines for Welding, Brazing, Hot and Cold Working, Heat Treating, Pickling and Finishing

Contents

H-2010F

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WELDING

General Welding

The welding characteristics of the HASTELLOY® corrosion-resistant alloys are similar in many ways to those of the austenitic stainless steels and present no special welding problems, if proper techniques and procedures are followed.

As a way of achieving quality production welds, development and qualification of welding procedure specifications is suggested. Such procedures are usually required for code fabrication, and should take into account parameters such as, but not limited to, base and filler materials, welding process, joint design, electrical characteristics, preheat/interpass control, and postweld heat treatment requirements.

Any modern welding power supply with adequate output and controls may be used with the common fusion welding processes. Generally, welding heat input is controlled in the low to moderate range. Wide weave beads are not recommended. Stringer bead welding techniques, with some electrode/torch manipulation, are preferred.

In general, nickel-based alloys will exhibit both sluggish welding and shallow penetration characteristics. Therefore, care must be used with respect to joint design and weld bead placement to insure that sound welds with proper weld bead tie-in are achieved. The nickel-based alloys have a tendency to crater crack, so grinding of starts and stops is recommended.

Cleanliness is considered an important aspect of welding of the corrosion-resistant nickel-based alloys. Contamination by greases, oils, corrosion products, lead, sulfur, and other low melting point elements can lead to severe cracking problems.

It is recommend that welding be performed on base materials that are in the solution annealed condition. Materials with > 7% outer Fiber Elongations of cold work should be solution annealed before welding. The welding of mateials have large amounts of residual cold work can lead to cracking in the weld metal and/or the weld heat affected zone. Welding processes that are commonly used with the corrosion-resistant alloys are shown in Table 1.

In addition to these common arc welding processes, other welding processes such as plasma arc welding, resistance spot welding, laser beam welding, electron beam welding, and submerged arc welding can be used. Because of the possibility of hot cracking, parameter selection is extremely important when using the submerged arc welding process to weld nickel-based alloys. Contact Haynes International for welding parameter and wire/flux recommendations.

The plasma arc cutting process is commonly used to cut alloy plate into desired shapes and prepare weld angles.

The use of oxyacetylene welding and cutting is not recommended, because of carbon pick-up from the flame.

TABLE 1

Process	American Welding Society Designation	Common Designation
Gas Tungsten Arc Welding, Manual and Machine	GTAW	TIG
Gas Metal Arc Welding, Manual and Machine	GMAW	MIG
Shielded Metal Arc Welding	SMAW	Stick or Coated Electrode

The fabrication techniques are considered straight forward and require no special tools, equipment, or highly trained personnel. Figure 9A shows the general configuration of this fabrication technique for flue gas desulfurization construction. As an alternative (Figure 9B), batten strips can be applied to cover the joints. This method is generally used in the chemical process industry.

Key points to consider during fabrication include:

- Lay out the installation pattern in advance.
- Develop welding parameters and train welders in advance.
- Preform sheet in shop whenever possible.
- Prepare substrate surface as necessary.
- Structually attach sheets to the substrate.
- Seal weld all-around.
- Inspect and test welds for leak tight condition.
- Repair questionable areas as necessary.

One of the important features of this fabrication technique is the lack of concern with substrate dilution of the weld metal during seal welding. As shown in Figure 9A, all seal welding is performed in an alloy to alloy configuration. Additionally, this technique reduces fabrication time due to the simplicity of overlapping one sheet onto another. Midsheet attachment can be used to insure the sheet is held flush with the substrate and to lessen concern about damage due to vibration.

There are several areas where shop formed parts can save time and effort. Edge and corner molding can be placed

GENERAL WELDING AND LAYOUT CONFIGURATION

Figure 9A

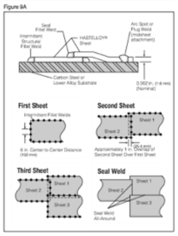
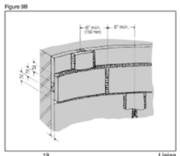
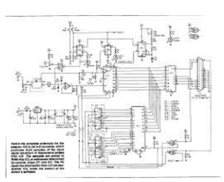


Figure 9B



Mechanical Integrity

- The Documentation can be voluminous
- Digital Storage and Management is Recommended
- Tracking Systems must be in Place



Mechanical Integrity

- Consider Using Technology. Most MI Programs Can Perform the Following:
  - Identification and list of all covered equipment, including piping circuits
  - Completed data sheets and a populated data base for each item
  - Criticality rating with probability and consequence of failure for each item
  - Documented visual inspections with inspection sketches or AutoCAD Drawings
  - Field verified and red-lined P&IDIs
  - Corrosion study to establish failure mechanisms
  - Process study to identify process systems and conditions for consequence analysis
  - Inspection and test plans based on equipment type, failure modes, and Criticality Rating
  - Inspection and testing according to the equipment plan
  - Deficiency reports identifying conditions that do not meet the acceptance criteria Recommendation Tracking
  - Updated equipment plans identifying future inspection and testing requirements

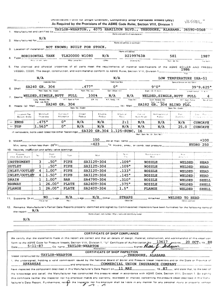
Inspection & Testing

1910.119(j)(4)

Inspections and tests shall be performed on process equipment. inspection and testing procedures shall follow recognized and generally accepted good engineering practices. The frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience. The employer shall document each inspection and test that has been performed on process equipment. The documentation shall identify the date of the inspection or test, the name of the person who performed the inspection or test, the serial number or other identifier of the equipment on which the inspection or test was performed, a description of the inspection or test performed, and the results of the inspection or test.

Inspection & Testing

- Inspection & Testing Activities Must Conform to the Requirements of the Applicable Code such as:
  - ASME
  - ANSI
  - ASTM
  - NFPA
  - CGA
  - And Any Other Applicable Codes



As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by TAYLOR-WHARTON., 4075 HAMILTON BLVD., THEODORE, ALABAMA. 36590-0568
2. Manufactured for N/A
3. Location of installation NOT KNOWN; BUILT FOR STOCK.
4. Type HORIZONTAL TANK TLH20000 W1080 N/A D2199763B 581 1987
5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 1986 to N/A N/A LOW TEMPERATURE UHA-51
6. Shell SA240 GR. 304 .477" 0" 9'0" 39'9.625"
7. Seams WELDED,SINGLE,BUTT FULL 100% N/A N/A WELDED,SINGLE,BUTT FULL 4
8. Heads: (a) Matl. SA240 GR. 304 (b) Matl. SA182 GR. 304 BLIND FLG.

ENDS	.475"	0"	N/A	N/A	2:1	N/A	N/A	N/A	CONCAVE
TOP	1.563"	0"	N/A	N/A	N/A	N/A	N/A	25.0	CONCAVE

If removable, bolts used (describe other fastenings) SA320 GR.304 1.125-8UNC, 16

9. MAWP 150 psi at max. temp. +100
Min. temp. (when less than -20°F) -423 °F. Hydro., pneu., or comb. test pressure HYDRO 250
10. Nozzles, inspection and safety valve openings:

INSTRUMENT	3	.50"	PIPE	SA312T-304	.109"	NOZZLE	WELDED	HEAD
OUTLET	1	.50"	PIPE	SA312T-304	.109"	NOZZLE	WELDED	HEAD
INLET/OUTLET	4	1.00"	PIPE	SA312T-304	.133"	NOZZLE	WELDED	HEAD
INLET/OUTLET	4	1.50"	PIPE	SA312T-304	.145"	NOZZLE	WELDED	HEAD
DRAIN	1	1.00"	BAR	SA479T-304	.310"	NOZZLE	WELDED	SHELL
MANWAY	1	26.00"	PLATE	SA240T-304	.375"	NOZZLE	WELDED	SHELL
FLANGE	1	26.00"	PLATE	SA240T-304	1.5"	FLANGE	WELDED	SHELL

11. Supports: Skirt NO Lugs N/A Legs N/A Other STRAPS Attached WELDED TO HEAD
12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: N/A

N/A

CERTIFICATE OF SHOP COMPLIANCE

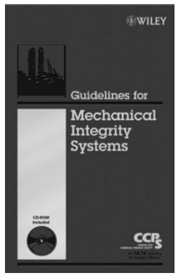
We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. "U" Certificate of Authorization No. 13617 expires 20 OCT. 19 88
Date 5-11-87 Co. name TAYLOR-WHARTON Signed

CERTIFICATE OF SHOP INSPECTION

Vessel constructed by TAYLOR-WHARTON at THEODORE, ALABAMA
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of ARKANSAS and employed by COMMERCIAL UNION INSURANCE COMPANY have inspected the component described in this Manufacturer's Data Report on 11 MAY, 19 87, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage

Inspection & Testing & CCPS

- The CCPS Book Contains Many Tables that are Useful in the Perfomance of Design, Inspection & Testing
- Let's Review Some of these Tables...



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Mechanical Integrity & CCPS

TABLE 9-1
RAGAGEPs for Pressure Vessels

Issuing Organization	Document		Application
	Number	Title	
API	API 510	Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration	Covers the maintenance, inspection, repair, alteration, and rerating procedures for pressure vessels.
API	Recommended Practice (RP) 572	Inspection of Pressure Vessels	Covers the inspection of pressure vessels.
API	ANSI/API 660 or International Organization for Standardization (ISO) 16812	Shell-and-Tube Heat Exchangers for General Refinery Services	Defines the minimum requirements for the mechanical design, material selection, fabrication, inspection, testing, and preparation for shipment of shell-and-tube heat exchangers.
ASME	ASME Code, Section VIII	ASME Boiler and Pressure Vessel Code (BPVC), Unfired Pressure Vessels	Provides requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels operating at either internal or external pressures exceeding 15 psig.
NBBPVI	National Board (NB)-23	National Board Inspection Code	Provides rules and guidelines for in-service inspection of boilers, pressure vessels, piping, and pressure relief valves (PRVs). Also provides rules for the repair, alteration, and rerating of pressure-retaining items and for the repair of PRVs.

Mechanical Integrity & CCPS

TABLE 9-2
RAGAGEPs for Atmospheric and Low-pressure Storage Tanks

Issuing Organization	Document		Application
	Number	Title	
API	RP 575	Inspection of Atmospheric and Low Pressure Storage Tanks	Covers the inspection of atmospheric and low-pressure storage tanks designed to operate at pressures from atmospheric to 15 psig.
API	620	Design and Construction of Large, Welded, Low-pressure Storage Tanks	Covers the design and construction of large, welded, low-pressure carbon steel aboveground storage tanks, including flat-bottom tanks that have a single vertical axis of revolution. Applies to tanks with pressure in their vapor spaces at not more than 15 psig.
API	650	Welded Steel Tanks for Oil Storage	Covers the material, fabrication, erection, and testing requirements for aboveground, vertical, cylindrical, closed- and open-top, welded steel storage tanks. Applies to tanks with internal pressures approximating atmospheric pressure.
API	653	Tank Inspection, Repair, Alteration, and Reconstruction	Covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks.

Mechanical Integrity & CCPS

TABLE 9-3
RAGAGEPs for Process Piping

Issuing Organization	Document		Application
	Number	Title	
ANSI	ANSI/ASME B31.3	B31.3 - Process Piping	Provides requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping.
API	API 570	Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems	Provides procedures for the inspection, repair, alteration, and rerating of metallic piping that have been in-service.
API	API RP 574	Inspection Practices for Piping System Components	Covers inspection practices for piping, tubing, valves (not including control valves), and fittings. This document is a supplement to ANSI/API 570.
NBBPVI	NB-23	National Board Inspection Code	Provides rules and guidelines for in-service inspection of boilers, pressure vessels, piping, and PRVs. Also provides rules for the repair, alteration, and rerating of pressure-retaining items and for the repair of PRVs.

Mechanical Integrity & CCPS

TABLE 9-4
RAGAGEPs for Pressure Relieving Devices

Issuing Organization	Document		Application
	Number	Title	
ANSI/ASME	ANSI/ASME B31.3	B31.3 - Process Piping	Provides requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping.
API	API 510	Pressure Vessel Inspection Code: Maintenance, Inspection, Rating, Repair, and Alteration	Covers the maintenance, inspection, repair, alteration, and rerating procedures for pressure vessels used by the petroleum and chemical process industries. Also covers inspection and testing of pressure relief devices.
API	RP 520	Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries, Part I - Sizing and Selection, Part II - Installation	Covers the sizing, selection, and installation of pressure relief devices for equipment that has a maximum allowable working pressure of 15 psig or greater.
API	RP 576	Inspection of Pressure Relieving Devices	Describes the inspection and repair practices for automatic pressure-relieving devices, including pressure safety valves (PSVs), pilot-operated PRVs, rupture disks, and weight-loaded pressure vacuum vents.
ASME	ASME B&PV Code, Section	ASME BPVC - Power Boilers	Provides requirements for all methods of construction and relief protection of power, electric, and miniature boilers, as well as high-temperature water boilers used in stationary service.
ASME	ASME B&PV Code, Section IV	ASME BPVC - Heating Boilers	Provides requirements for design, fabrication, installation, and inspection of steam generating boilers, and hot water boilers intended for low-pressure service that are directly fired by oil, gas, electricity, or coal. It also covers methods of checking safety valve and safety relief valve capacity.
ASME	ASME B&PV Code, Section VIII	ASME BPVC - Pressure Vessels	Provides requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels operating at either internal or external pressures exceeding 15 psig. Also provides requirements for pressure vessel relief devices.
NBBPVI	NB-23	National Board Inspection Code	Provides rules and guidelines for in-service inspection of boilers, pressure vessels, piping, and PSVs. Also provides rules for the repair, alteration, and rerating of pressure-retaining items and for the repair of PSVs.

Mechanical Integrity & CCPS

TABLE 9-5
RAGAGEPs for Instrumentation and Controls

Issuing Organization	Document		Application
	Number	Title	
API	RP 551	Process Measurement Instrumentation	Provides procedures for installation of the more generally used measuring and control instruments and related accessories.
API	RP 554	Process Instrumentation and Control	Covers performance requirements and considerations for the selection, specification, installation, and testing of process instrumentation and control systems.
API	API 555	Process Analyzers	Addresses the associated systems, installation, and maintenance of analyzers.
ASME	CSD-1	Controls and Safety Devices for Automatically Fired Boilers	Covers requirements for the assembly, maintenance, and operation of controls and safety devices installed on automatically operated boilers that are directly fired with gas, oil, gas-oil, or electricity, subject to certain service limitations and exclusions.
International Electrotechnical Commission (IEC)	IEC 61508-SER	Functional safety of electrical/electronic/ programmable electronic safety-related systems	Sets out a generic approach for all safety life-cycle activities for systems comprising electrical, electronic, and/or programmable electronic components that are used to perform safety functions.
ISA	ISA S84.01	Application of SISs for the Process Industries	Provides a safety life cycle and requirements for design, installation, and maintenance of SISs.
ISA	ISA-TR-84.00.02 Parts 1 through 5	Safety Instrumented Functions (SIFs) – Safety Integrity Level (SIL) Evaluation Techniques	This series covers the different evaluation techniques that can be used to determine if a specific SIS design satisfies the SIL requirements defined in the SIF.
ISA	ISA-91.00.01	Identification of Emergency Shutdown (ESD) Systems and Controls that Are Critical to Maintaining Safety in the Process Industries	Provides general requirements for determining safety-critical ESDs and controls, and for maintaining the identified instrumentation.
NFPA	NFPA 85	Boiler and Combustion Systems Hazards Code	Discusses the fundamentals, maintenance, inspection, training, and safety for the reduction of combustion system hazards.

Mechanical Integrity & CCPS

TABLE 9-6
RAGAGEPs for Pumps

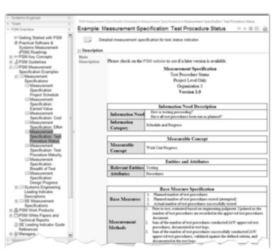
Issuing Organization	Document Number	Document Title	Application
ANSI	ANSI/ASME B73.1	Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process	Covers centrifugal pumps of horizontal, end suction single stage, centerline discharge design. Includes dimensional interchangeability requirements and certain design features to facilitate installation and maintenance.
ANSI	ANSI/ASME B73.2	Specification for Vertical In-Line Centrifugal Pumps for Chemical Process	Covers motor-driven centrifugal pumps of vertical shaft, single stage design with suction and discharge nozzles in-line. Includes dimensional interchangeability requirements and certain design features to facilitate installation and maintenance.
ANSI	ANSI/ASME B73.3	Specification for Sealless Horizontal End Suction Centrifugal Pumps for Chemical Process	Covers sealless centrifugal pumps of horizontal, end suction single stage, centerline discharge design. Includes dimensional interchangeability and features to facilitate installation and maintenance.
API	610	Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries	Specifies requirements for centrifugal pumps, including running in reverse as hydraulic power turbines.
API	674	Positive Displacement Pumps - Reciprocating	Covers the minimum requirements for reciprocating positive displacement pumps.
API	675	Positive Displacement Pumps - Controlled Volume	Covers the minimum requirements for controlled volume positive displacement pumps.
API	676	Positive Displacement Pumps - Rotary	Covers the minimum requirements for rotary positive displacement pumps.
API	681	Liquid Ring Vacuum Pumps and Compressors	Defines the minimum requirements for the basic design, inspection, testing, and preparation for shipment of liquid ring vacuum pumps and compressors.
API	682	Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps	Specifies requirements and provides suggestions for sealing systems for centrifugal and rotary pumps.

Inspection & Testing

- Comply with all Manufacturer's Requirements if Acceptable To the Process
- If Not, Support Your Selected Requirements by:
  - Engineering Analysis
  - Risk Based Inspection Process
  - RAGAGEP
  - FMEA

Inspection & Testing

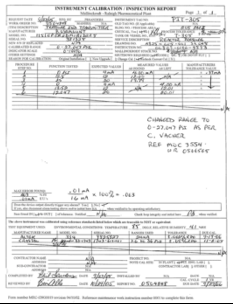
- Must be Documented
- CCPS Recommends Documentation of the Following:
  - Equipment Identifier
  - Date Inspection Performed
  - Description of Task Performed
  - Results of the Test or Inspection
  - Fitness for Service Evaluation
  - Any Parts or Materials Used
  - Qualification or Certification Records for Performing Tasks
  - Identified Deficiencies
  - Remaining Life Calcuations
  - Recommendations on Next Due Date of Inspection or Testing



Inspection & Testing & CCPS

The Key to Effective Inspection & Testing

- All Inspections & Testing Must Be:
  - Documented
  - Completed in the Required Time Frame in Order to Maintain Integrity
  - Tracked to Completion



INSTRUMENT CALIBRATION / INSPECTION REPORT

Quality Assurance

1910.119(j)(6)

In the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used. Appropriate checks and inspections shall be performed to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions. The employer shall assure that maintenance materials, spare parts and equipment are suitable for the process application for which they will be used.

Quality Assurance & Code Compliance

- The Design, Installation Procedures, Repairs, and Temporary Repairs Must Conform to the Requirements of the Applicable Code such as:
  - ASME
  - ANSI
  - ASTM
  - NFPA
  - CGA
  - Any Other Applicable Codes

De Dietrich

Quality Assurance & CCPS

- CCPS Details that Quality Assurance Activities Exist for All of The Life Cycle Stages of Equipment
  - Design/Engineering
  - Procurement
  - Fabrication
  - Receiving
  - Storage & Retrieval
  - Construction & Installation
  - In-Service Repairs, Alterations and Re-Rating
  - Temporary Installations & Repairs
  - Decommissioning and reuse

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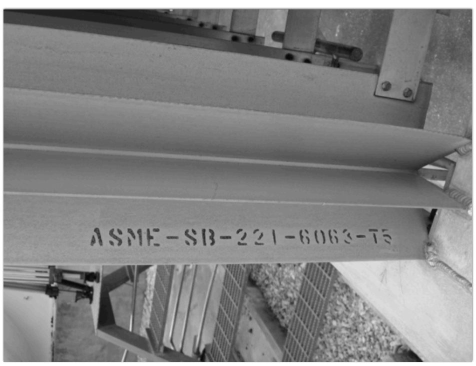
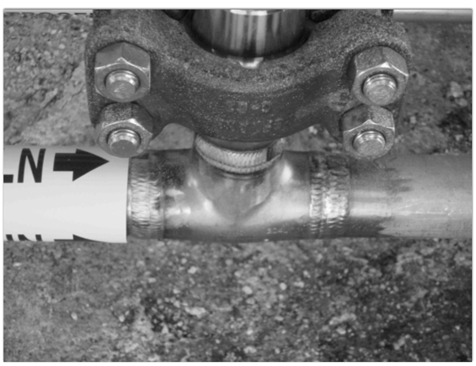


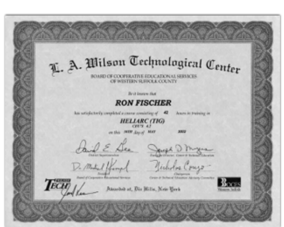
Quality Assurance

- Just Like Inspection & Testing
- Comply with all Manufacturer's Requirements if Acceptable To the Process
- If Not, Support Your Selected Requirements by:
  - Engineering Analysis
  - Risk Based Inspection Process
  - RAGAGEP
  - EMEA



Quality Assurance

- For Maintenance Operations, Quality Assurance Might Also Require:
  - Certified Welders
    - In the Process to be Welded
  - AISC Trained Steel Erectors
  - Other Recognized Certifications



MI Process & CCPS What We Must Consider

TABLE 9-13
Mechanical Integrity Activities for Pressure Vessels

New Equipment Design, Fabrication, and Installation		*Inspection and Testing*		*Preventive Maintenance*		*Repair*	
Activity	*Frequency*	*Activity*	*Frequency*	*Activity*	*Frequency*	*Activity*	*Frequency*
Example Activities and Typical Frequencies							
• Equipment specification, Vessel data sheet • Process design requirements • Materials selection • Vendor/Shop qualification • Equipment design by manufacturer • Design approval by owner • Welding/Quality control (QC) plan approval • Equipment fabrication • Inspection • Documentation preparation • Installation/ Commissioning • Acceptance and turnover	As required for fabrication and installation	External visual inspection	5-year maximum	• Activities identified from RCM or similar work planning initiatives, such as: • Routine visual surveillance • Process conditions monitoring/ tracking • Process performance monitoring	As required to meet preventive maintenance schedule or process monitoring needs	• Equipment replacement-in-kind • Unique vessel repair activities such as weld overlay, alterations, hot taps, or welding attachments to the pressure boundary • Painting • Insulation/Fireproofing repair • Chemical cleaning • Structural support and anchoring systems repair or renewal	As required by the condition of the equipment based on recommendations from ITPM activities or observations from normal operations
		Thickness measurement	½ corrosion life or 10-year maximum				
		Internal inspection or alternatively on-stream inspection (as applicable)	½ corrosion life or 10-year maximum, thickness measurement suffices if corrosion rate is less than 5 mils per year				
		Additional inspections for specific degradation modes (e.g., corrosion under insulation)	As required by condition of equipment and rate of degradation				

MI Process & CCPS What We Must Consider

TABLE 9-13 *(Continued)*

New Equipment Design, Fabrication, and Installation	*Inspection and Testing*	*Preventive Maintenance*	*Repair*
Technical Basis for Activity and Frequency			
QA practices for pressure vessels	Scheduled with intervals set by the results of previous activity or at fixed intervals based on inspection code (API 510 or National Board Inspection Code [NBIC]) or jurisdictional requirements	Company or jurisdictional requirements	Performed when indicated by failure during normal operations or by the results of ITPM activities
Sources of Acceptance Criteria			
ASME PV codes for design and fabrication, in conjunction with more stringent requirements in company engineering standards and in facility-specific or jurisdictional requirements for the pressure boundary	Acceptance criteria from inspection codes API 510, NBIC, and/or jurisdictional requirements. Acceptance criteria for damage from specific degradation modes per API RP 579	Company requirements and good engineering practices, coupled with upper and lower safe limits for process conditions as defined in the process safety information (such as pressure, temperature, fluid composition, and velocity limits)	Design and fabrication codes: ASME PV codes, in conjunction with more stringent requirements in company engineering standards, or facility or jurisdictional requirements. In general, repairs and alterations are performed in accordance with ASME "R" stamp requirements
Typical Failures of Interest			
Incorrect material or weld metal, incorrect heat treatment, incorrect dimensions, misalignment or out-of-square flanges, leak during testing, weld defects, high hardness readings, use of unqualified welder or welding procedures	• Distortion of pressure boundary, leakage from cracks (e.g., fatigue, environmentally induced, stress corrosion cracking, caustic cracking), or holes in pressure boundary. Corrosion of pressure boundary, including corrosion under insulation • Lack of grounding, and excessive corrosion of structural support and anchoring systems	• Distortion of pressure boundary, leakage from cracks (fatigue or environmentally induced), or holes in pressure boundary. • Corrosion of pressure boundary, including corrosion under insulation. Lack of grounding, and excessive corrosion of structural support and anchoring systems	Incorrect material or heat treatment, incorrect dimensions, misalignment or out-of-square flanges, leak during testing, weld defects, high hardness readings, use of unqualified welder or welding procedures
Personnel Qualifications			
Company requirements and documented skills, NDE qualifications, inspection certifications or technical training for inspection and acceptance activities	Documented qualifications, industry inspection certifications (API 510 or NBIC), or specific technical training to analyze results	Tasks usually require craft-specific skills or operator-specific skills that are addressed within their respective training programs	Welders qualified per Section IX of the ASME Code. NDE technicians qualified in appropriate techniques. Industry inspection certifications (API 510 or NBIC) or specific technical training for pressure vessel engineering

Now…What About Risk Based Mechanical Integrity?

What is It?
What Should You Expect to See?

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RBMI - Based on API 580/581

- Risk-based approaches for inspection and testing of fixed equipment for mechanical integrity (API 580/581) and for the integrity of Safety Instrumented Systems (ANSI/ ISA-84 -IEC 61511 Mod) are well established.
- RBI for pressured fixed equipment is defined by a minimum set of requirements in API RP 580 - Risk-Based Inspection. RP 580 presents the principals and minimum general guidelines for implementing and sustaining an RBI program. Much of the technology in its application is described in API RP 581 - Risk-Based Inspection Technology

Thomas J. Folk P.E. Lloyd's Register Capstone, Inc.

RBMI – Effective PM

An effective PM program should:

- improve plant reliability and plant safety – a shift away from reactive maintenance and the resulting operational issues
- provide a rational basis for the development of PM program activities and their intervals based on RAGAGEP (Recognized and Generally Accepted Good Engineering Practice) or sound engineering and reliability principles
- using a structured logical approach that will provide consistent results create and document appropriate PM strategies for plant equipment with their basis (including targeted damage mechanisms and affected components/parts)
- provide risk-based prioritization with resulting improved effectiveness integrate EHS and economic driven PM activities
- document results and respond to non-conformances found by PM activities via appropriate review, repairs, or as PM program revisions
- track compliance to the PM activities schedule evaluate program results and effectiveness
- collect failure data needed to support and update risk-based PM strategies and equipment selection for replacements and capital projects.

RBMI Facts

- Best-in-class distributions are <10% reactive, and ~50% predictive.
- Organizations without focus can exceed 50% in reactive work.
- The transition from Traditional MI to RBMI requires not just a strong PM program, but strong planning and scheduling discipline among other aspects of an asset-management program.

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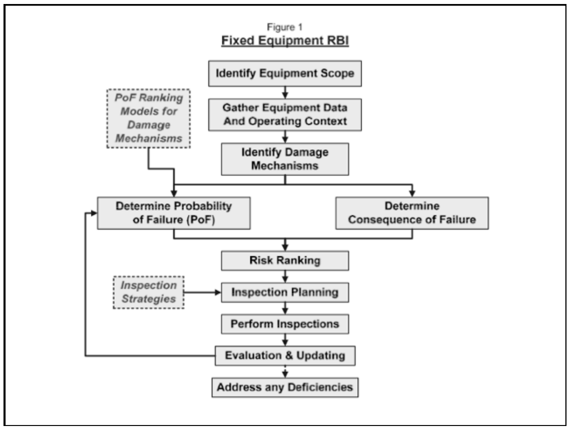

Sample – RBI Fixed Equipment Inspection Strategy

Pressure Vessel – Visible External Deterioration

by External Visual Inspection

	Risk Rank			
	Low	**Medium**	**Medium-High**	**High**
Minimum External Visual coverage [1]	100% External Visual	100% External Visual	100% External Visual	100% External Visual
Maximum Interval (Yrs.), or ½ remaining life	15	10	10	5
Maximum Interval allowed by jurisdiction	Depends on Jurisdictional Requirements	Depends on Jurisdictional Requirements	Depends on Jurisdictional Requirements	Depends on Jurisdictional Requirements
Inspection Confidence:				
Non-insulated	Very High	Very High	Very High	Very High
Insulated	Medium	Medium	Medium	Medium

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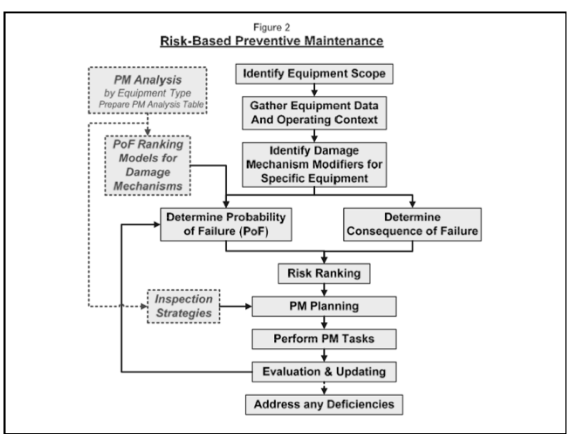

Simplified PM Analysis Table with Sample Entries

PM Analysis Table – Centrifugal Pump						
	Component or Part	**Damage Mechanism**	**Damage Cause**	**Consequence Type**	**Time to Repair (days)**	**PM Types**
	Bearing – Antifriction	Wear	Normal Wear	OoS	1	Vibration Monitoring
	Bearing – Antifriction	Wear	Contamination	OoS	1	Oil Analysis Oil Change
	Bearing – Antifriction	Loss of Lubrication	Oil Leak	OoS	1	Operator Rounds
	Bearing – Antifriction	Excessive Vibration	Imbalance	OoS	1	Vibration Monitoring
	Bearing – Antifriction	Excessive Load	Operational Error	OoS	1	Vibration Monitoring
	Mechanical Seal	Wear	Normal Wear	**LoC** OoS	1	Operator Rounds
	Pump Casing	Thinning	Corrosion	**LoC** OoS	360	Internal Inspection Rebuild UT thickness measuring
	Belt (V belt drive)	Wear	Normal Wear	OoS	0.5	Inspect & Re-tension Replace

OoS – Out of Service – not available for use
LoC – Loss of Containment – Process fluid leakage

PM Strategy - Generalized Listing for Example Only

Component Types	Damage Mechanism & Component / Part	Activity	Extent - See Activity Procedure for details	High	Med-High	Medium	Low
Centrifugal Pump	Bearing Failure Coupling Failure Seal Failure etc	Vibration Monitoring	Vibration Monitoring of all Components (1)	Daily (1)	1 Month	3 Months	N/R
Centrifugal Pump	Loss of capacity due to internal wear or corrosion	Performance Monitoring	Check actual flow and head developed versus pump curve (2)	1 Year	2 Year	N/R*	N/R
Centrifugal Pump	Oil contamination, Bearing Failure, Seal Failure	Change Oil	Change Oil in Sump	3 Months	6 Months	1 Year	1 Year
Mechanical Coupling Grease Lube	Coupling Failure	Re-grease	Inspect and add new grease.	3 Months	6 Months	1 Year	1 Year
Cog Belt Drive	Belt and/or Sheave failure, High bearing loads	Re-tension or replace belts	Inspect and re-tension or replace belts. (3)	2 Year	5 Year	N/R	N/R

Notes:
1) For High Criticality continuous on-line monitoring is recommended
2) If pumps are run in parallel add Medium criticality pumps at 2 Years
3) For High or Med-High Criticality with only turnaround availability for PM - Replace belts at these intervals

The Possible Results of RBMI

- Reliability of the Process Will Improve
- PM Will Move From Reactive to Predictive
- The best in class have 30 to 50% lower maintenance costs and huge differences in on-stream performance.

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Anatomy of a Disaster What Happens When Mechanical Integrity Is Not Followed

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BP Texas City

- BP Was Not Following the Requirements of PSM
- System Integrity Was Not Maintained
- Mechanical Integrity Was Not Followed

The Result…

15 Killed 180 Injured $50.6 Million Fine

Mechanical Integrity Primary Goal

"***Maintain System Integrity***"

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Process Safety Management of Highly Hazardous & Explosive Chemicals

Mechanical Integrity
What Does it Actually Mean?