

**Drum Level Instrumentation
and
The ASME Boiler Code
Requirements**

**for
Minnesota Boiler Inspectors**

April 21, 2016

Presented by: Clark-Reliance

Topics

- **Direct and Indirect Reading Instruments**
- **ASME Code Section I Requirements for Drum Level Instrumentation (Steam Boilers that operate > 15 PSI)**
- **Water Columns and Water Gage Isolation Valves**
- **Water Gage Glasses and rules for construction**
- **Magnetic Level Gages**
- **Code Design Requirements for Isolation Valves**
- **ASME Code Section IV Requirements for Boilers <15 PSI)**
- **Level Switch requirements for HRSG applications**
- **CSD-1 Applications**
- **Low Water Cutouts**
- **Common Code Violations**
- **Section VII Recommended Proper Care for Power Boilers**

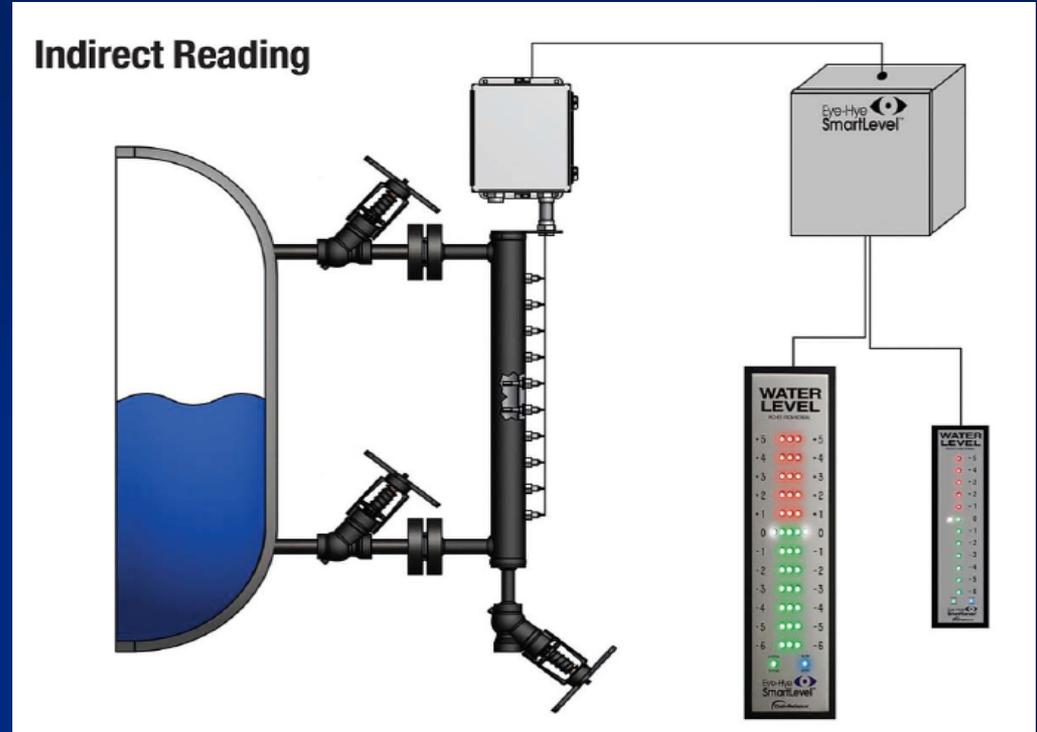
ASME Code General Terms

Direct Reading Gage



Glass Gage

Remote Reading



Indirect Reading

Level Indicator

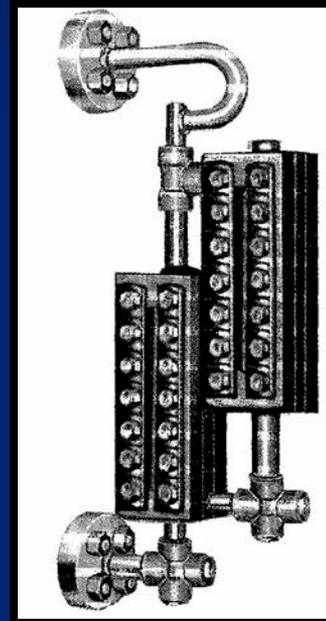
Direct Reading Gage Glasses



**Tubular Glass
to 250 PSI
(1.7MPa)**



**Prismatic
(Reflex)
to 350 PSI
(2.4 MPa)**



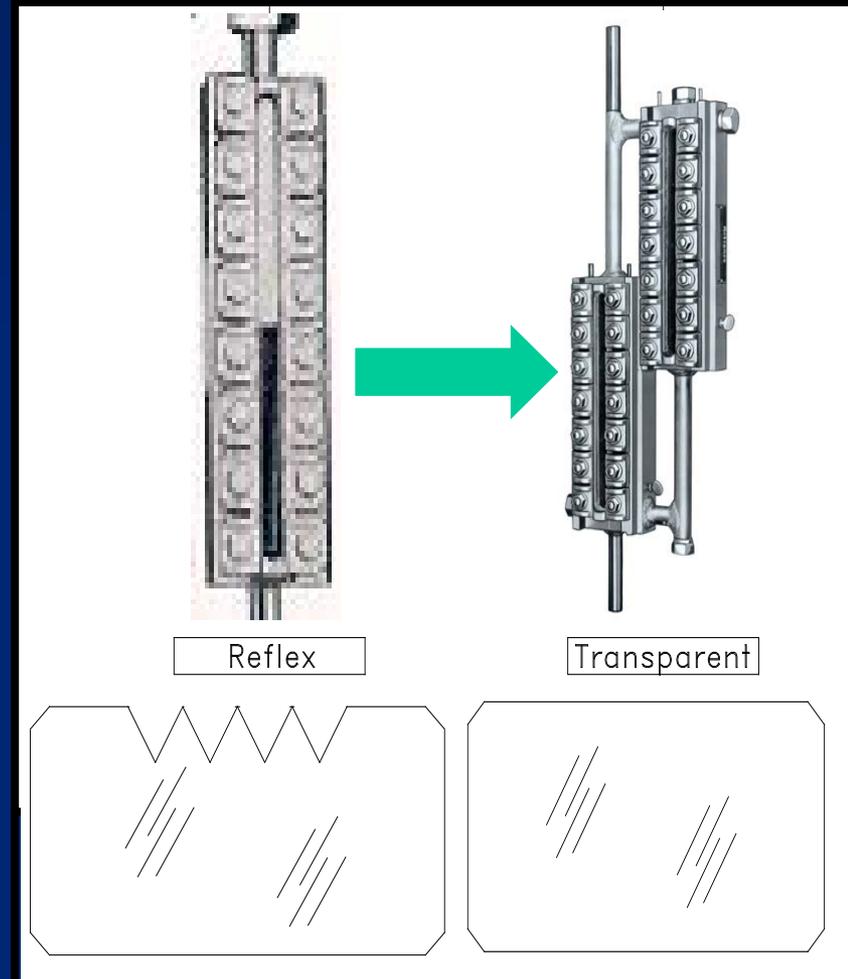
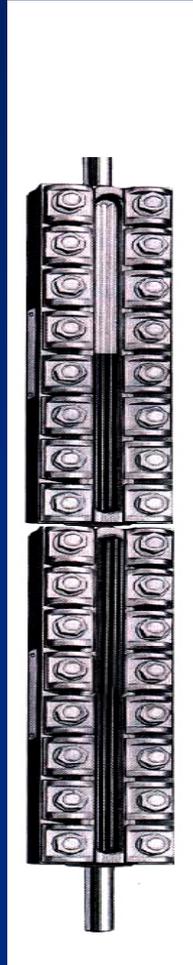
**Flat Glass
(Transparent)
to 2000 PSI (14 MPa)**



**Bi-Color
(Ported)
to 3000 PSI
(21 MPa)**

End-to-End Reflex Gage Glasses Are Permitted

- PG.60.1 Clarifies the use of multi-section gages without overlap, due to the light refraction principle
- Transparent Type Multi-section gages do require a 1" minimum overlap



Structural Webs are Prohibited from Flat Glass Gages Designs

- These Webs may mask the actual location of the water level
- The risk of Masking the level is enhanced on elevated gage glass installations



Flat Glass Transparent Type Water Gage Glasses with LED Illumination

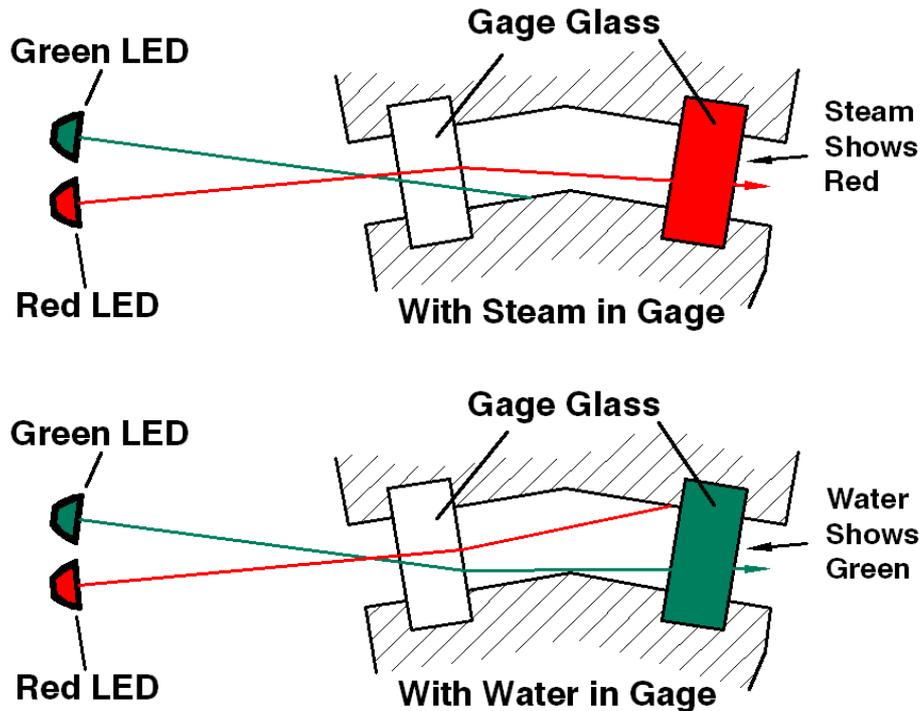


Typical View of Water Level with no obstructions in the viewing area. The gage must be illuminated, as needed for the level to be readily visible by the operator.

Bi-Color Water Gage Principle of Operation

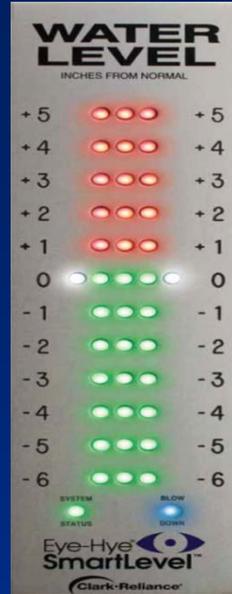
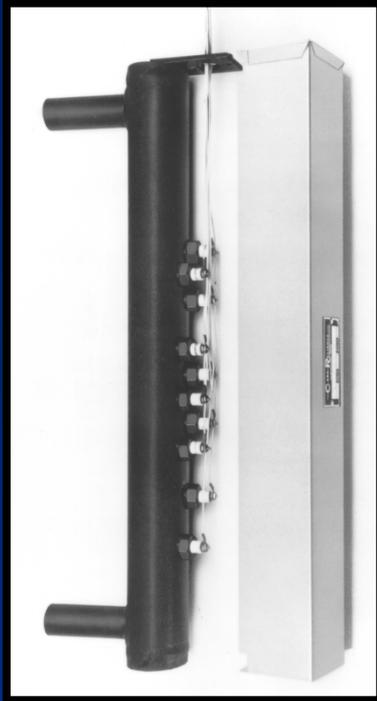
Water shows **GREEN** Steam shows **RED**.

(Light refracts differently through water than steam with glasses on specific angles)



Bi-Color Gages must be outfitted with an illuminator to be Code Compliant

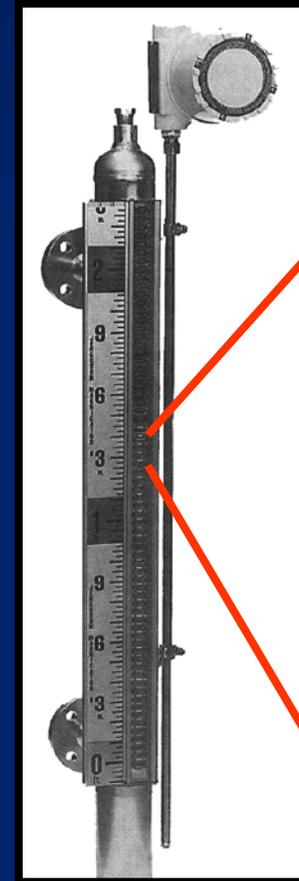
Remote (Indirect) Level Indicator Technologies



Conductivity Type

Plus other common technologies:

- Differential Pressure Transmitters
- Guided Wave Radar



Magnetic Level Gage
(equipped w/ 4-20 transmitter)

Remote (Indirect) Level Indicators

- All Differential Pressure and Guided Wave type Indirect Level Indication instruments must be installed and programmed to the manufactures instructions to prevent indication errors.
- Precautions must be taken to prevent adverse effects from freezing conditions on the level sensing components
- Insulation on all piping is recommended, except on the Condensate Pots for DP transmitters. Install cages or guards to protect personnel, if service area is confined

Section I Requirements

Water Gage Requirements:

Operating up to 400 PSIG (3 MPa)

One Direct Reading Gage Required
(which must be kept continuous service)

Operating over 400 PSIG (3 MPa)

Two Direct Reading Gages in service

or

Two Remote (Indirect) Level Indicators

On Continuous Display for the

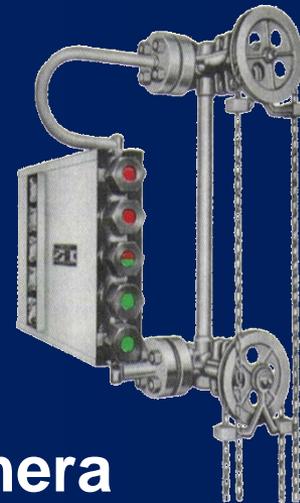
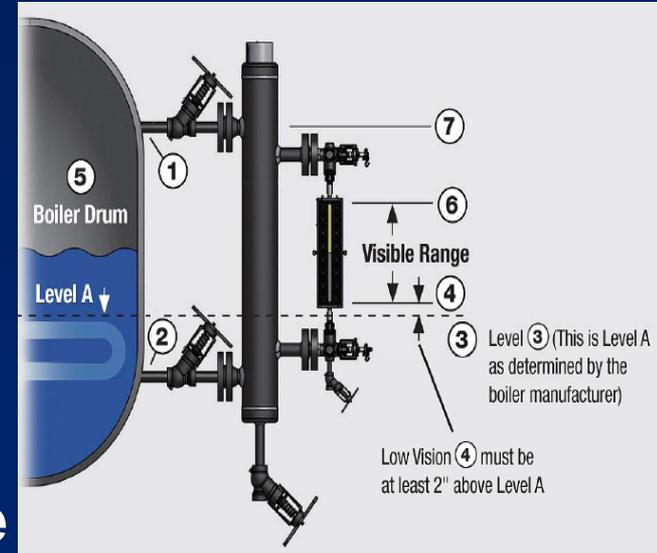
Operator and One Direct Reading Gage

(Which may be Isolated but kept in serviceable condition)

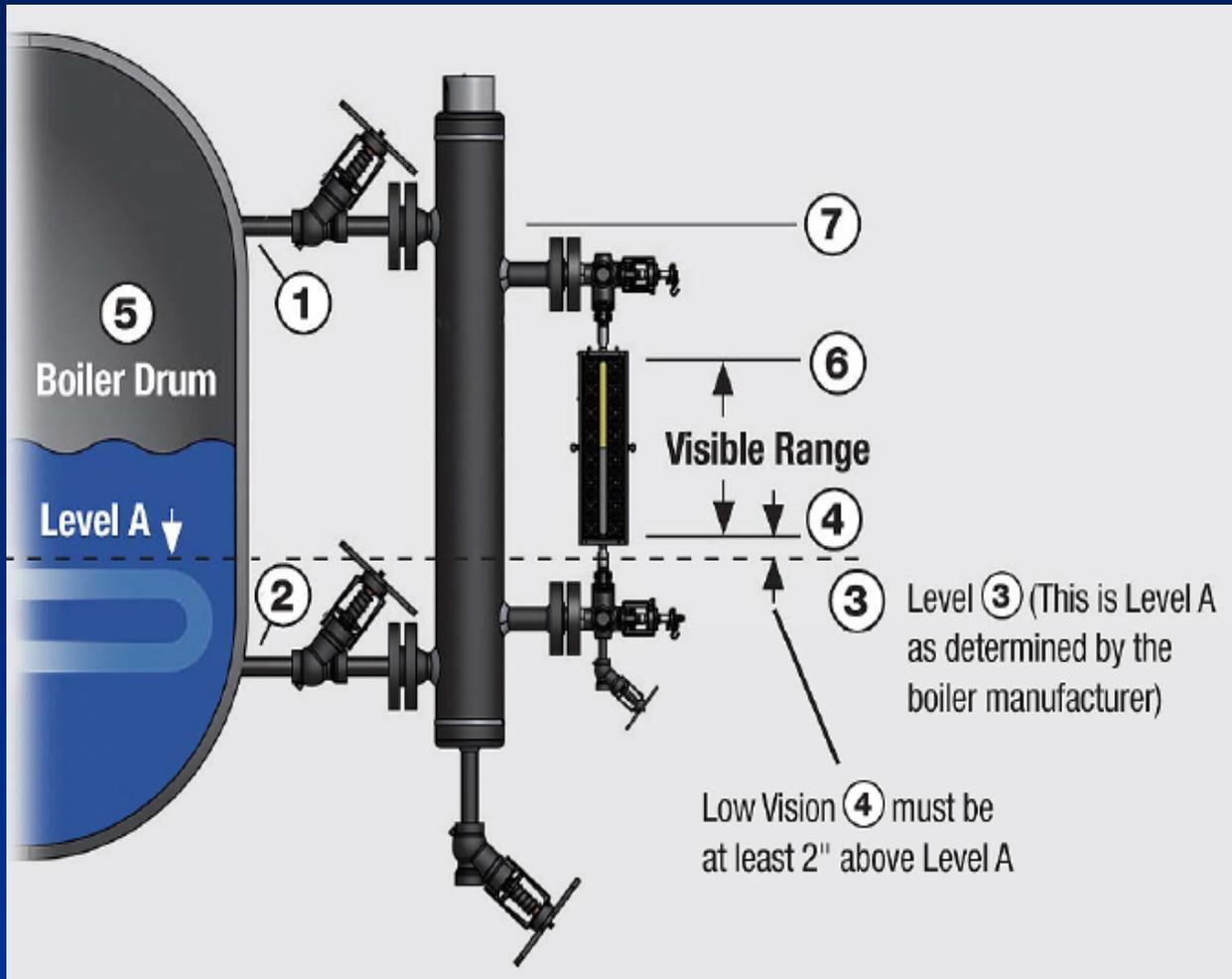
or

One gage glass in continuous service with a camera
system combined with an Indirect Remote Level

Indicator



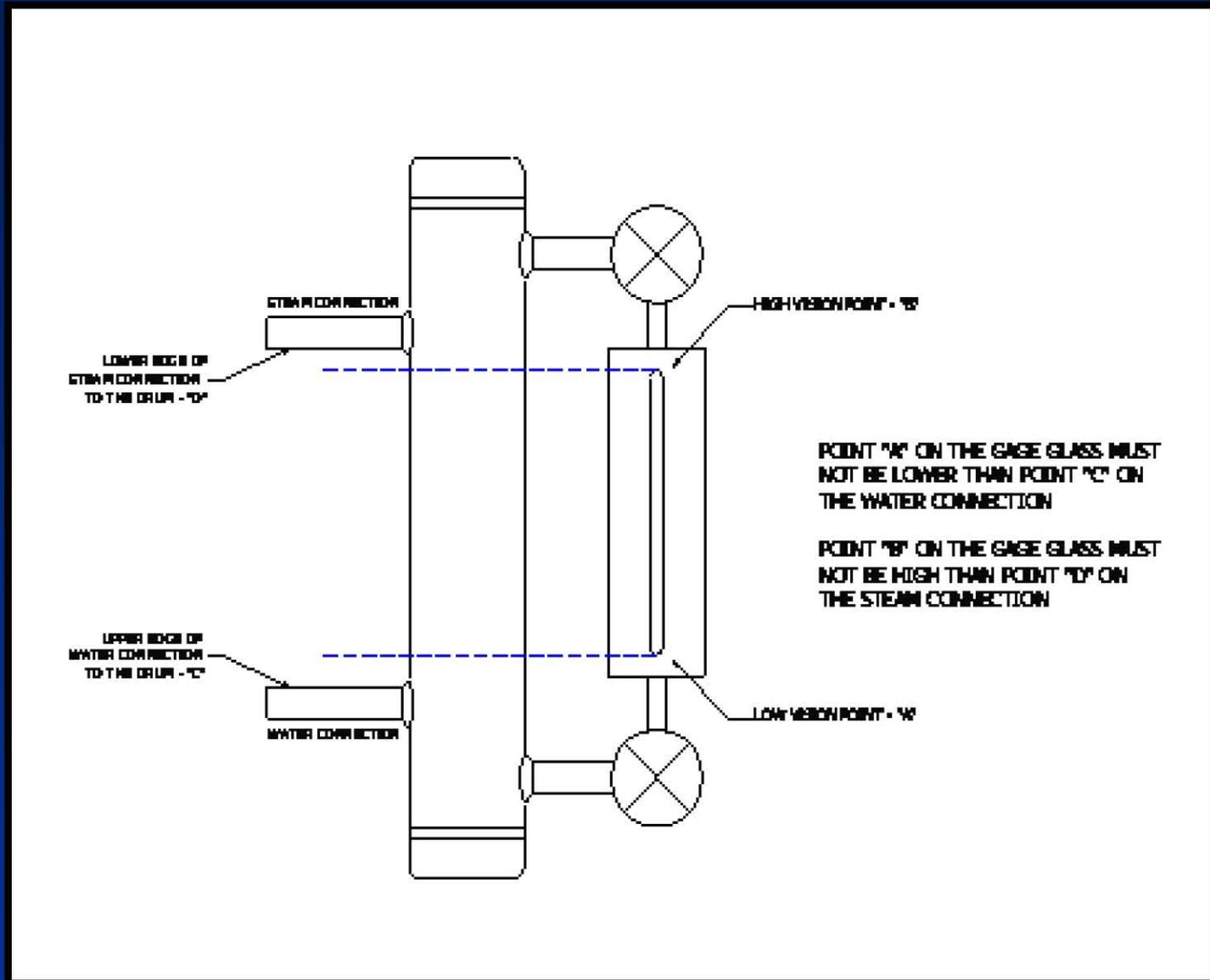
Section I Requirements for Gage Glass Placement



- 1- Lower side steam conn.
- 2- Upper side water conn.
- 3- Level A
- 4- Low vision
- 5- Drum
- 6- High vision
- 7- Steam conn.

Level "A" = Lowest Permissible Water Level, at which there will be no danger of overheating the boiler

Code Requirements for Gage Glass Placement



The Gage Glass Visibility must not intersect the pipe diameters on the boiler drum

Water Gage Glass Placement Explained

- **1.** Water Connection piping to the Water Column must be level or slope upward from the drum.
- **2.** Steam Connection for Water Column must be level or slope downward from drum to column.
- **3.** Level A = Lowest Permissible Water Level at which there will be no danger of overheating, as determined by the boiler manufacturer.
- **4.** The lowest visible part of water gage glass-Must be at least 2” above the lowest permissible water level (Level A).
- **5.** The highest visible part of water gage glass-Must be at least 1” below the center of the steam connection from the drum
- **6.** The lowest visible part of the water gage glass must be at least 1” above the center of the water connection from the drum.
- **Note:** the above information for 5 & 6 is based on 1-1/2” maximum pipe size from the vessel

Water Columns

- Provide a means to support Gage Glasses and alarms or Low Water Cutouts
- Cast Iron is permitted up to 250 PSI (1720 kPa)
- Steel construction used up to 3000 PSI (21 MPa)

Water Columns and Standpipes (Tie Tubes)

Water Columns are not required on Power Boilers by ASME Boiler Code, but when specified, must be designed and manufactured to comply with Code

Gage Cocks (Trycocks) have not been required since 1991 (Ref: PG-60.4)

Some operators continue to rely on Gage Cocks

Gage Cocks →



Section I - References

Water Columns (PG-60.2)

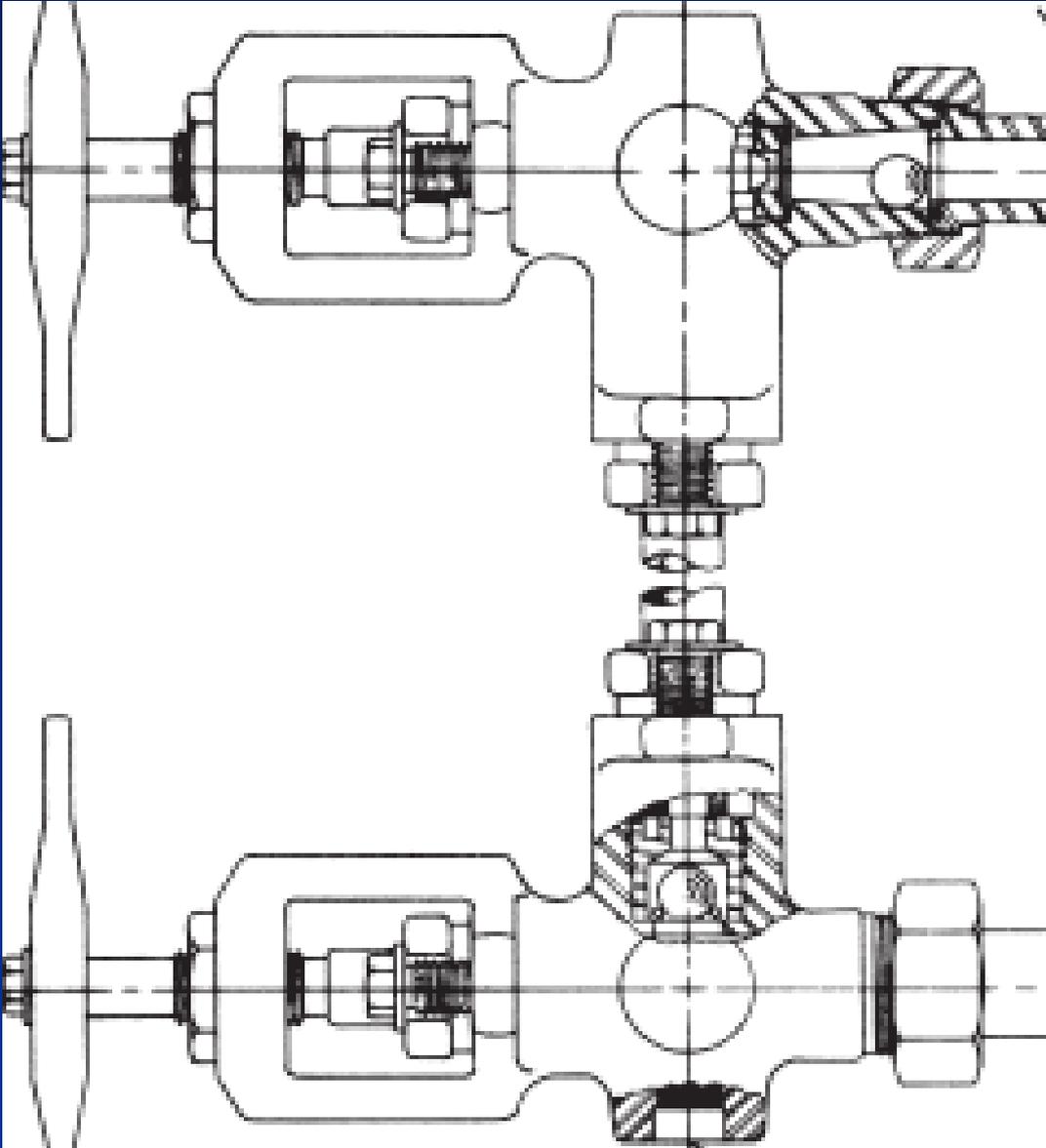
- 1" min. connections for water column to boiler drum (PG-60.3.4) →
- 3/4" min. drain connection (PG-60.2.3)
- Stainless Steel construction for water columns is prohibited (PG-12.3)

Water Level Indicators (PG-60.1)

- Water Gage Glass Requirements (PG-60.1.1)
- 3/4" min. connection size for Remote (Indirect) level indicators (PG-60.3.4)
- Highest & Lowest visible permissible water level (PG-60.1)
- Isolation and Drain Valve Requirements (PG-60.1.2)
- 1" Gage overlap requirement for Transparent Gages (PG-60.1), since 1996
- Transverse or Cross Web Structural Webs are prohibited from the construction of Transparent (Flat Glass) Water Gages, which may obstruct the view of the level (PG60.1), as of 2009
- Stainless Steel is permissible for Gage Glass Body construction (PG-12)
- Magnetic (Float Type) Level Gages are permitted up to 900 PSI (PG-12), as of 2007
- Gage Cocks not required since 1991 (→) See image above
- **Ball Checks in Water Gages Valves** considered to be a user option, if specified, must meet the Code requirements (Automatic Shut Off Valves – Appendix A-18)



Ball Check Specifications, when Applied



Typical upper Ball Check shown and designed so the steam flow will not completely close

The lower Ball Check must rise vertically to prevent risk for a trap of water in the gage glass

Pressure Limits for Threaded Connections for External Piping from PG.39.5.2

3/4" to 3" NPS (DN) & PSI (MPa)

3/4" (20) & smaller = 1500 PSI (10)

1" (25) = 1200 PSI (8)

1-1/4" (32) = 1000 PSI (7)

1-1/2" (40) = 900 PSI (6)

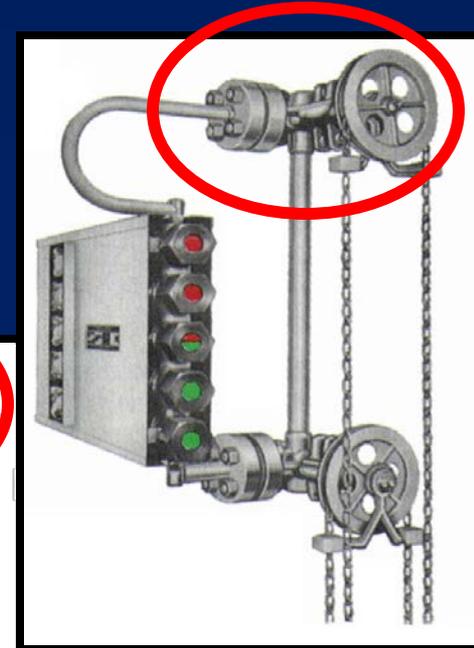
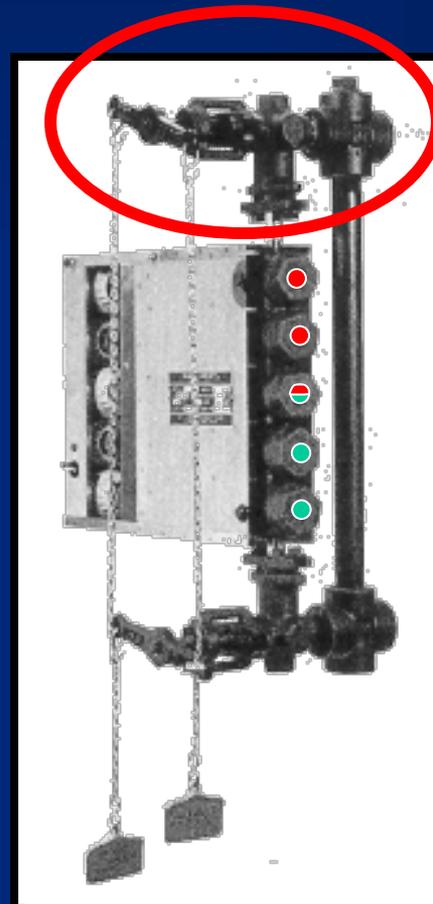
2" (50) = 600 PSI (4)

2-1/2" (65) = 500 PSI (3.5)

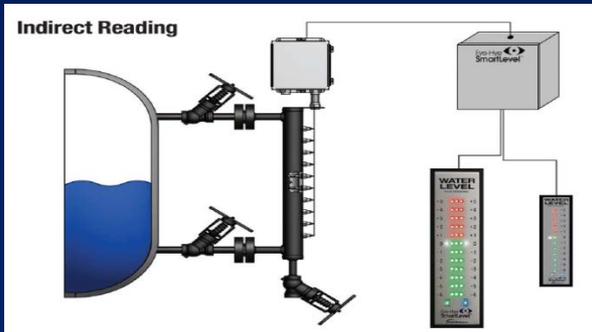
3" (80) = 400 PSI (3)

Always Install Chain Operators for Operator and Plant Safety

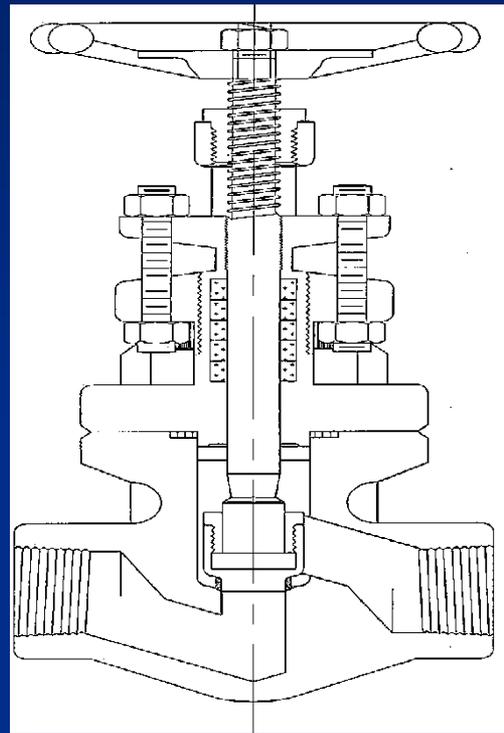
PG.60.1.2 requires a means to operate the isolation valves from the operating floor or platform



Globe Valves for Isolation and Drain

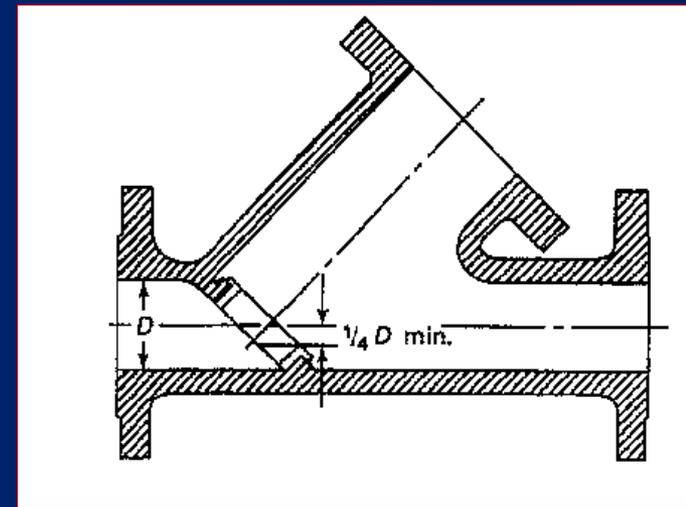


In-line flow prevents sediment or condensate traps, which can lead to false level indication with traditional Globe valves



Incorrect

Globe type valves are now permitted if the lowest edge of the seat is at least 25% of the port diameter.
(Ref: PG-60.3.7)

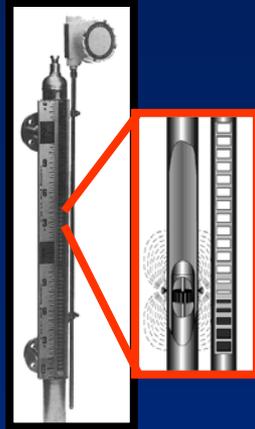


Correct

Section I Valve Requirements

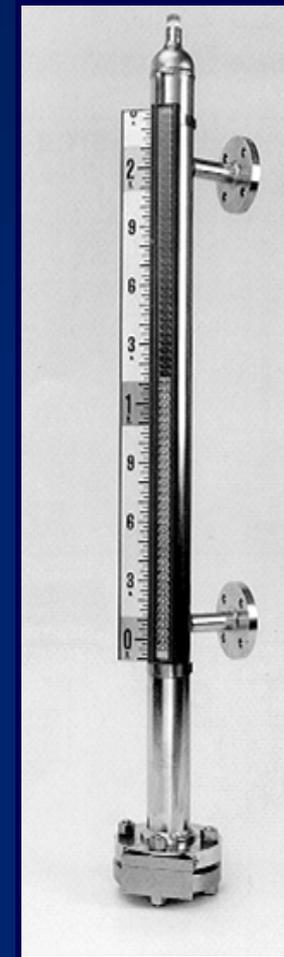
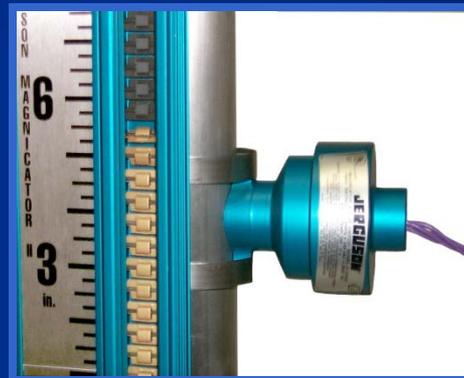
- Isolation valves installed between the drum and a water column are optional and when installed they must be locked open, to prevent unauthorized use.
- Isolation (shut off) and drain valves must be installed for any level indicating instrument (Ref: PG-60.1.2)
- Vent valves are not required

Magnetic Water Level Gages are Permitted up to 900 PSI (7 MPa)



Magnetic Level Gage (equipped w/ 4-20 transmitter)

External switches
Are not permitted
for control purposes,
such as
Low Water Cutouts
(PG-12 and PG-60)



For Process



For
Power
Boilers

Indication Scale

Code Issues and Concerns for the Use of Magnetic Level Gages on Boiler Drums

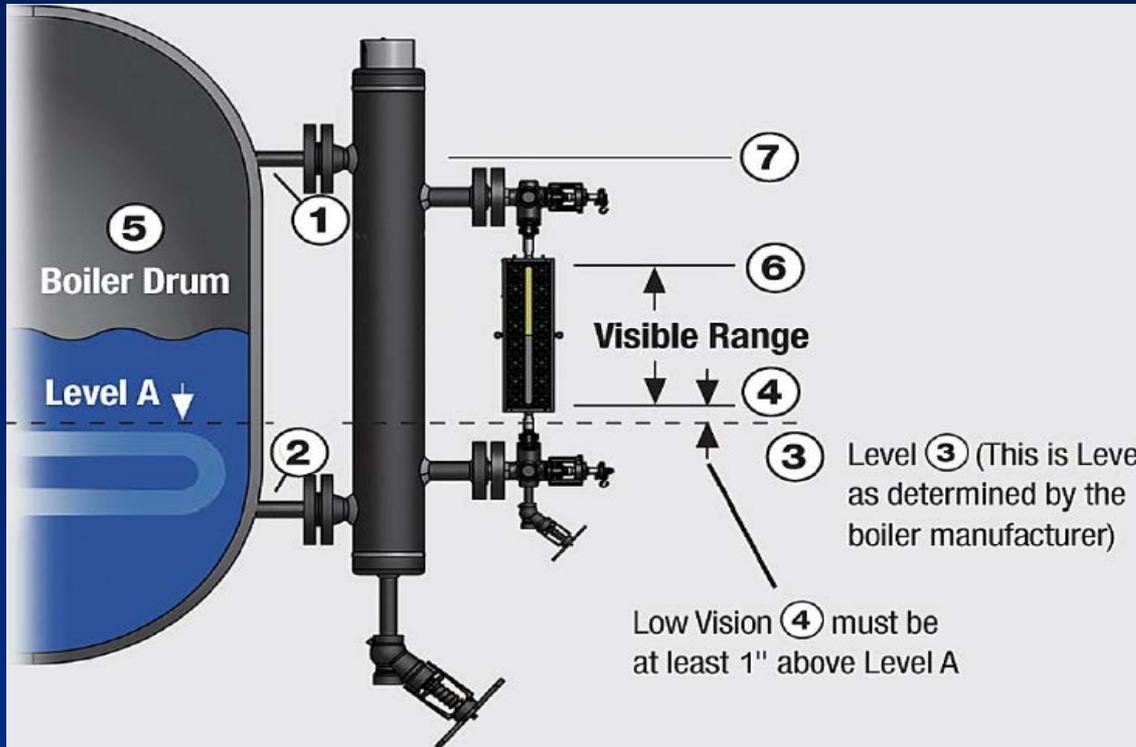
- Acceptable as an acceptable Indirect Reading for applications Gage up to 900 PSI (Ref: PG12.2)
- The Indication Scale must follow ASME guidelines (Ref: PG-60.3.2 & PG60.3.3)
- May not be used to support a water Gage glass, due to prohibition of stainless steel construction for water columns. Ref: PG-12.3
- No accessories are permitted to be attached for control purposes (No Trip Switches). This device must be used for indication only. Ref: PG-60.1.1.4

NOTE: The use of a Magnetic Level Gage does not replace the Code requirement for a Direct Reading Water Gage Glass on any Power Boiler Drum designed to meet the ASME Section I Boiler Code

Concerns for the Application of Magnetic Water Gages on Boiler Drums

- The float design is based on the operating conditions(customer specified), not the boiler design conditions. Therefore, if the boiler is operated at a pressure lower than the planned operating pressure, the Magnetic Gage reading will be higher than the actual drum level.
- If the user has poor water quality, the potential exists for iron particles to attach onto the float. This will result in a heavier float, with an inaccurate level reading.

Section IV Requirements for Gage Glass Placement



- 1- Lower side steam conn.
- 2- Upper side water conn.
- 3- Level A
- 4- Low vision
- 5- Drum
- 6- High vision
- 7- Steam conn.

4- Low Vision must be 1" above Level "A"

Level "A" = Lowest Permissible Water Level, at which there will be no danger of overheating the boiler

Section IV - References

Water Level Indicators (HG603)

- Water Gage Glass Requirements (1 or more required)
- 1/2" min. connection size for Gage Glass valves and Remote (Indirect) Level Indicators
- Low vision requirement
- Lowest permissible water level must be permanently marked on the vessel or outer jacket
- Isolation and Drain Valves are required
- One indirect level sensing device may be used with the gage glass isolated, but a gage glass must remain installed



Water Columns (HG604)

- 1" min. connections for water column to boiler drum
- 3/4" min. drain connection
- No shut off valves of any type shall be placed in the piping between the water column or cutout device and the boiler

Section IV - References

Low Water Cutouts (HG606)

- **Must be installed and approved for this service**
- **Must activate before the water falls below the lowest level in the gage glass**

ASME CSD-1

(Controls and Safety Devices for Automatically Fired Boilers)

- **Applications:**

Boilers within the fuel input range

>400,000 Btu/hr and < 12,500,000 Btu/hr

- **Ref: Section CW-140 for High Pressure
Steam Boilers**

Low Water Cutouts – CSD-1

Section CW-140 requires two separate devices

- The two devices must be in separate chambers and connected to separate water nozzles from the drum, but they may be connected to the same steam nozzle.

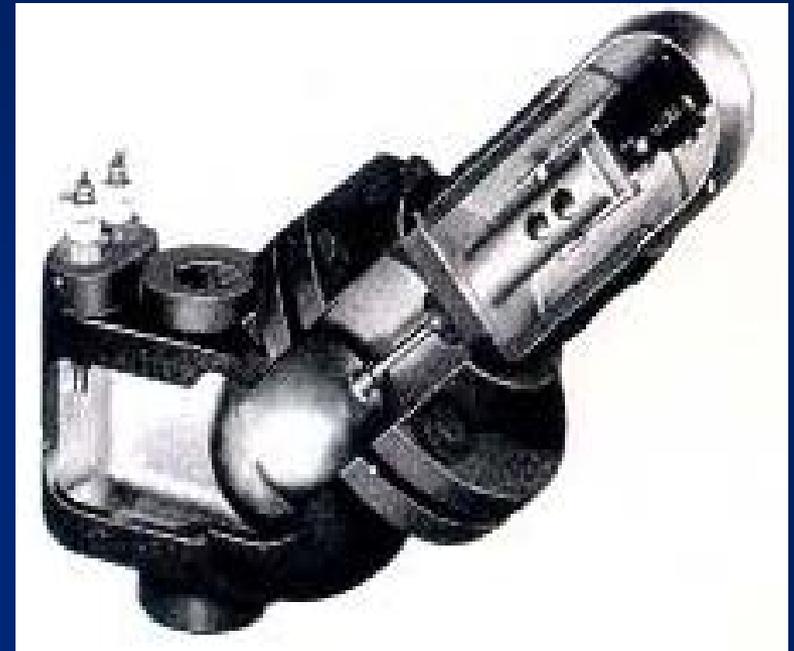
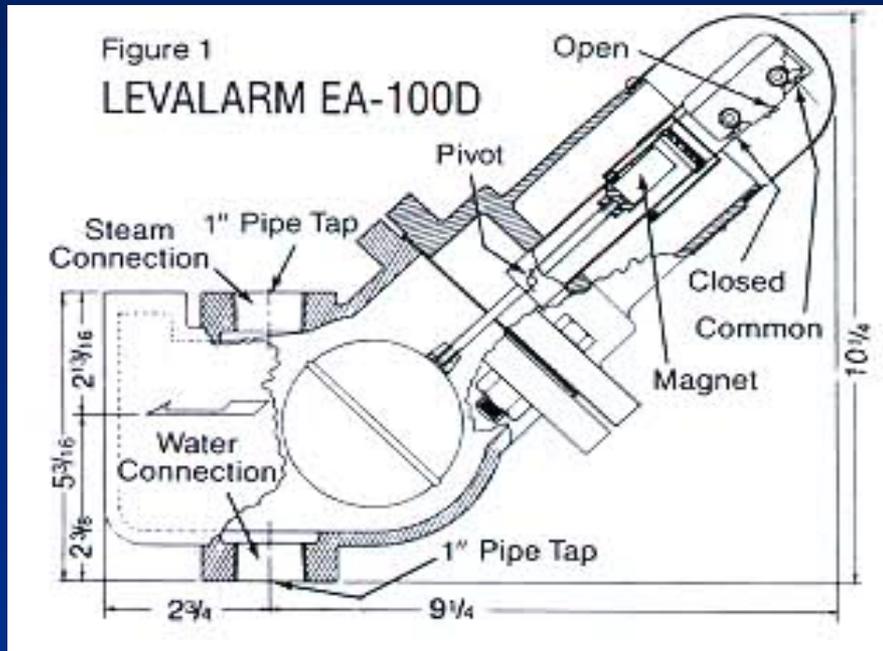
Note: One of the devices may be inserted directly into the boiler.

- Minimum pipe connection size is 1" with a vertical drain at least $\frac{3}{4}$ NPS

Low Water Cutouts Continued

- One control must be set to activate ahead of the other one
- The cutout circuit may include a time delay not to exceed 90 seconds or the manufacturer's recommendation (whichever is less)
- A Manual Reset function may be applied to the lower of the 2 controls

Low Water Cutout Example (Float Type)



Typical Float Actuated

Float and Probe Actuated
(for redundancy only)
Note: Does not meet CSD-1
requirements for 2 separate
controls

Example Probe type Low Water Cutouts



Figure 8
COMPACT
DESIGN,
VERSATILE
OPERATION



Typical
Conductivity Probe



Probe Model
attached to a
water column

Probe Model

Probes may also be installed directly into a water column

Code Violation with Low Cutout

The low level cut out probe actuation level is below the bottom of the gage glass

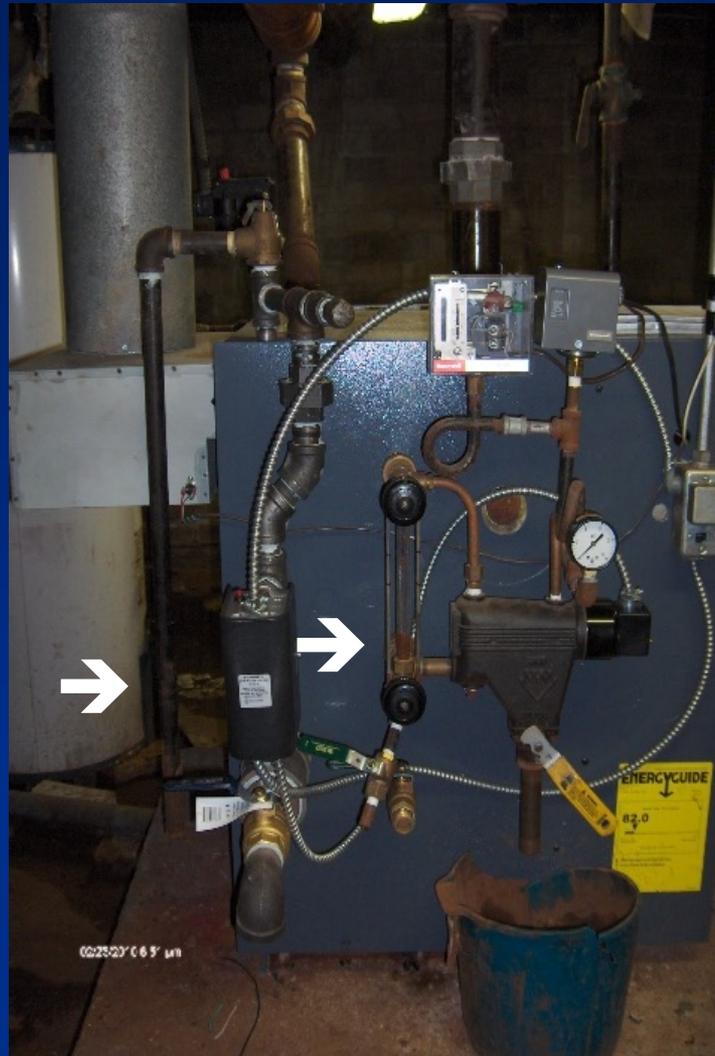


Photo courtesy of HSB

National Fire Protection Association (NFPA 85) Requirements for HRSG's

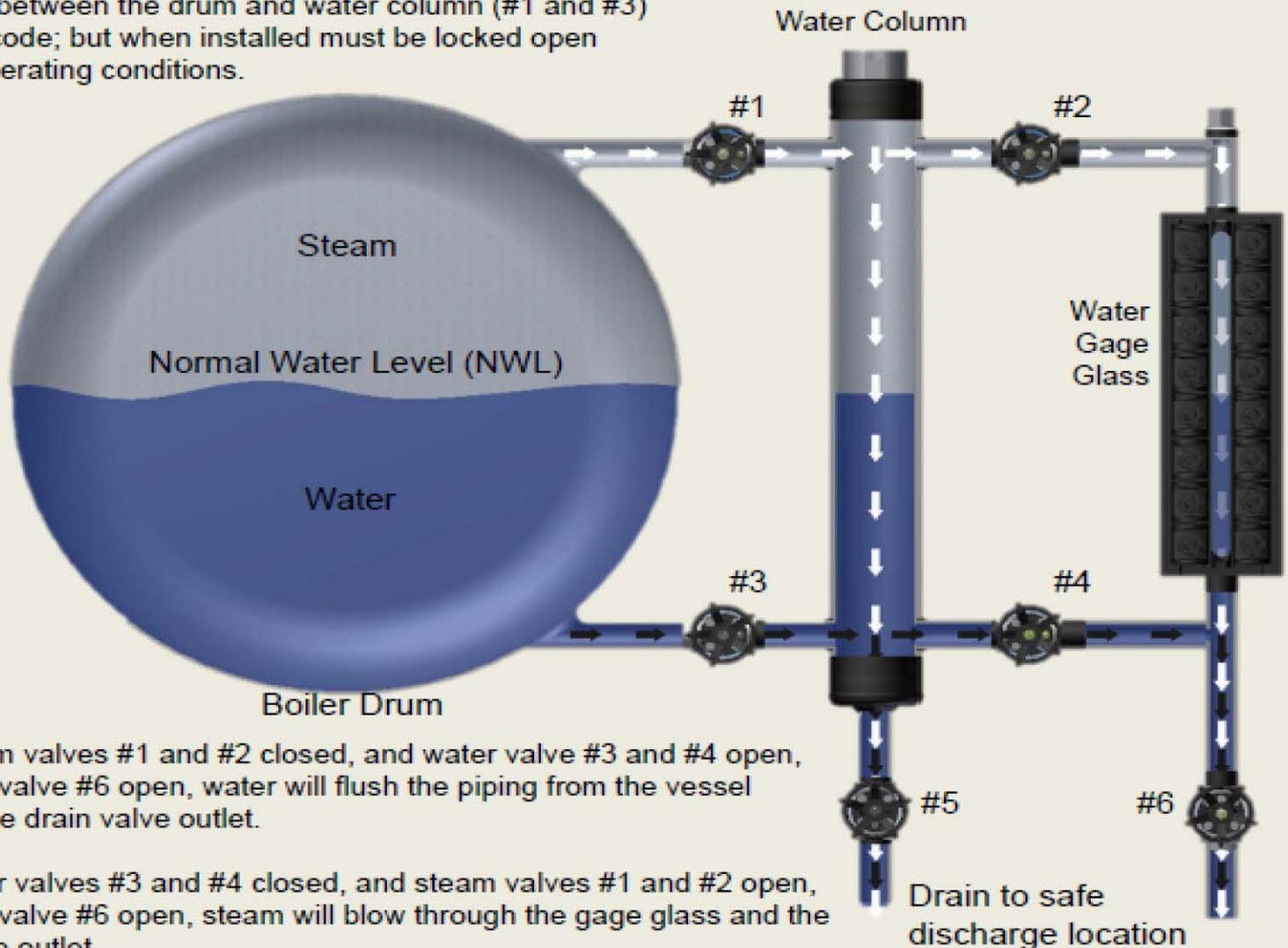
- **Water Level in each drum is continuously monitored and recorded or logged (Ref: 8.7.2.3)**
- **Operator receives Audible and Visual Alarms for Low Water Level (Ref: 8.7.3.2.1)**
- **Duct Burner Master Fuel Trip from Low Water Level on the high pressure drum section (Ref: 8.7.4.3)**

Recommended Guidelines for the Care of Power Boilers- Section VII

- Check water level in 2 or more instruments prior to start up and verify when a deviation is observed
- Keep Water Gage Glasses clean and easy to read, confirm there is no deviation that could be mistaken as water level
- Water Gages should be properly illuminated for easy observation
- Excessive blow down may cause premature wear of the gage internals
- Verification of high and low water alarms is critical to the prevention of carryover or damage to drum internals

Blowdown Procedure

Isolation valves between the drum and water column (#1 and #3) are optional by code; but when installed must be locked open under normal operating conditions.



Notes:

- 1) With steam valves #1 and #2 closed, and water valve #3 and #4 open, and drain valve #6 open, water will flush the piping from the vessel through the drain valve outlet.
- 2) With water valves #3 and #4 closed, and steam valves #1 and #2 open, and drain valve #6 open, steam will blow through the gage glass and the drain valve outlet.
- 3) Valve #5 is the code required drain valve for the water column.

Drain to safe discharge location

Common Code Violations and Concerns

- **Isolated Inoperable Water Gages**
- **Missing Water Gage Glasses**
- **Missing Illumination from Ported type gages**
- **Inadequate display of remote Level Indicators in the control room combined with isolated gages**

Common Code Violations and Concerns Continued

- **Contaminated Water Gage Glasses that prevent viewing the actual level (meniscus line)**
- **Multiple Section Flat Glasses without the Code required overlap**
- **Poor Maintenance Practices**

Code Violations

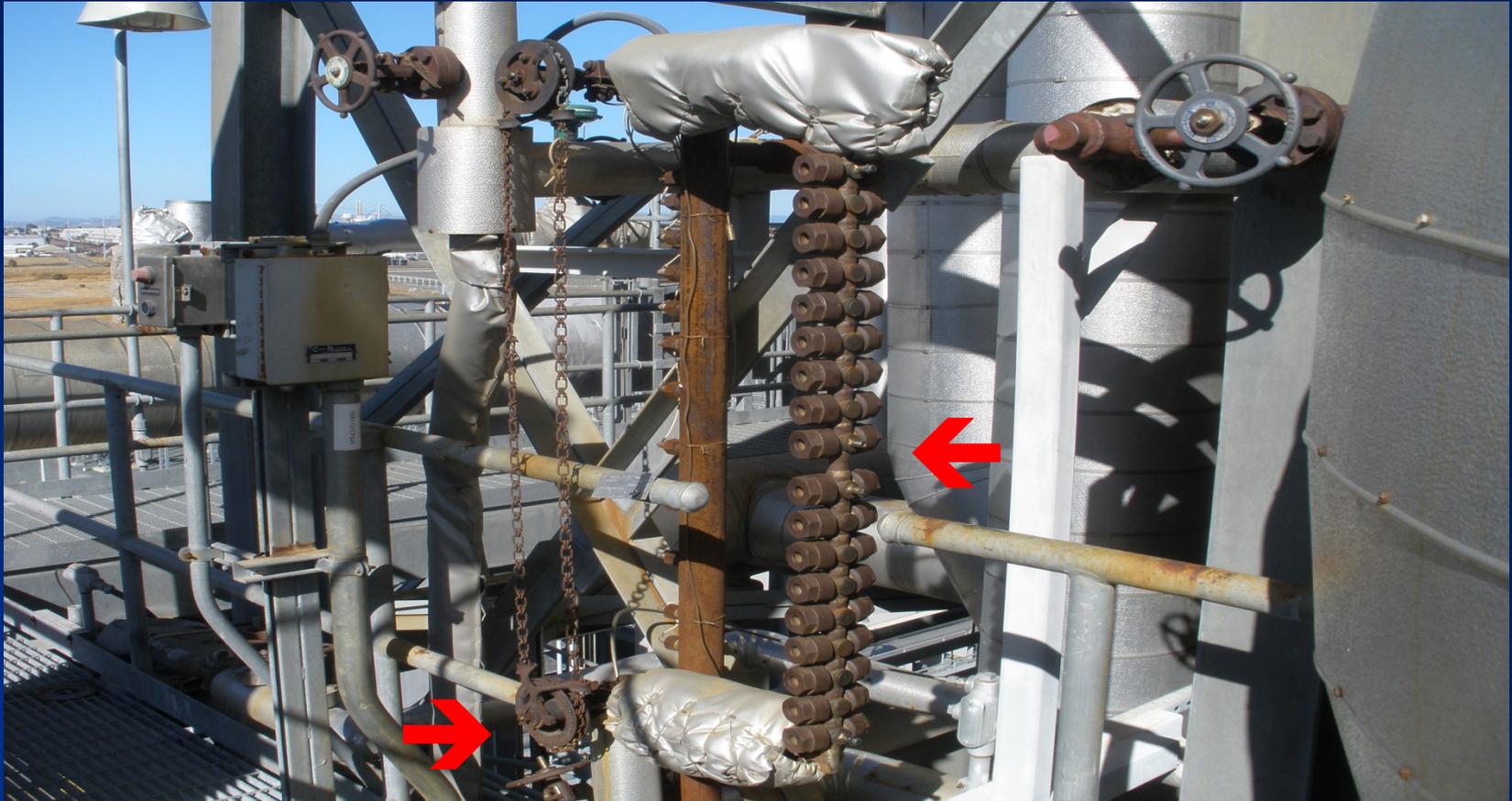


A drain valve is missing on this lower water gage valve



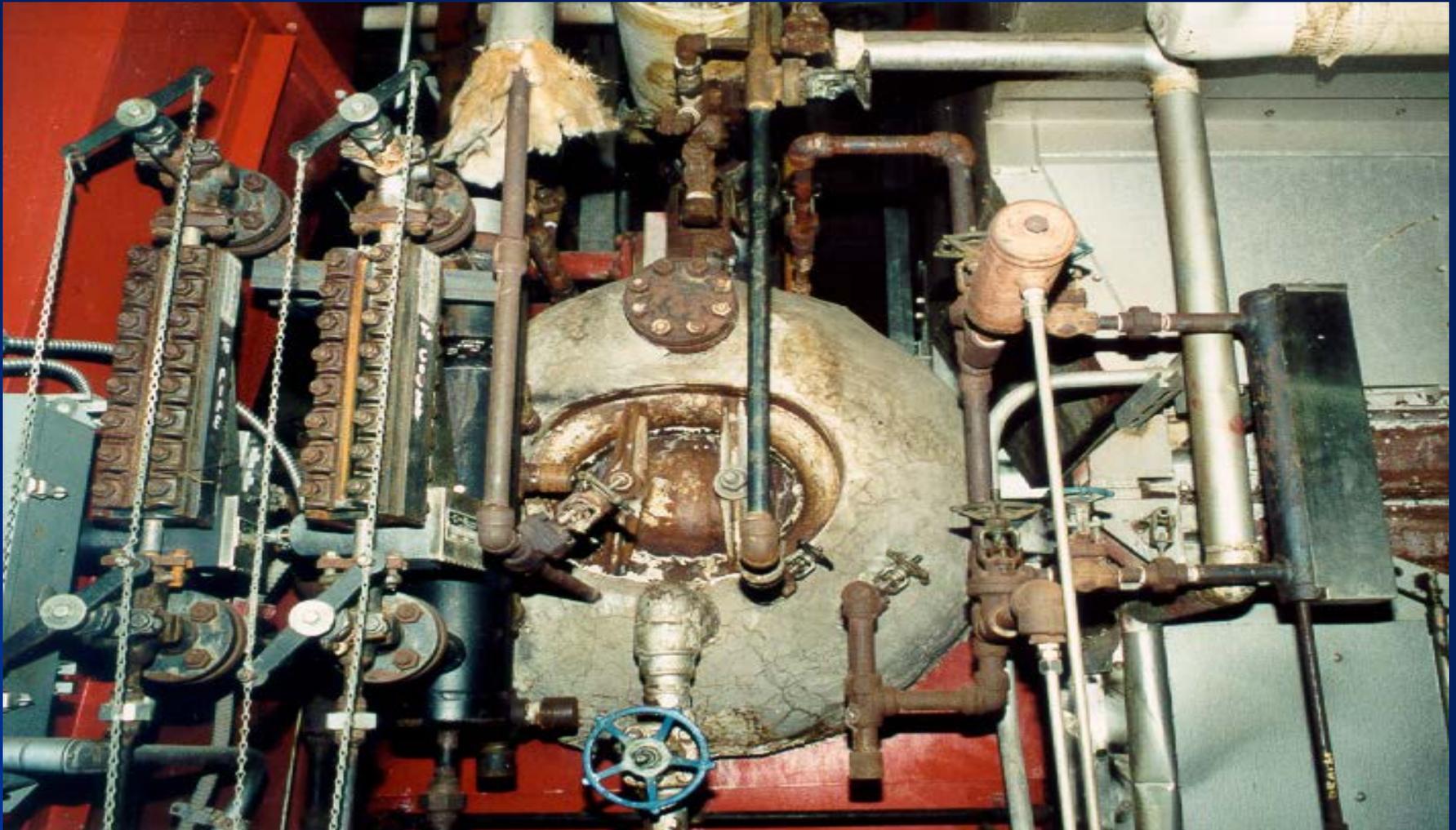
Magnetic Level Gage Scale extends below lower connection, it will always indicate some level

Code Violations



Illumination missing from the ported type gage glass
Note: The Chain wheel operated valves should not be linked together, because both valves will not shut tight

Drum Level Instrumentation



↑ This low point must have a drain valve

Photo of Serious Installation Error



Code Violation and Operation Risk to Boiler

Photo of Corrected Installation



Summary Recommendations for Drum Level Instrumentation Installations for Users

- **Specify or Install Code Compliant Designs**
- **Examine Piping and isolation Valves for leaks, missing insulation, and sediment traps**
- **Consult with the Insurance Underwriter or Plant Safety Department for plant requirements, which may exceed Code minimum**
- **Always follow the OEM maintenance instructions for the most accurate and reliable information**

Top Questions for Users

- Are you having any operational issues with Water Gage Glasses on Boiler Drum applications?
- What instruments are installed for the display Drum Level Indication in the Control Room?
- Are the water level limit controls on your boiler applications working properly and tested regularly?
- Does the existing Drum Level Instrumentation meet the Code for the Design and Operating Pressures of your Boiler Drum?

Summary Recommendations for Technology on Drum Level Instrumentation

- **Install LED Illumination for Water Gage Glass applications to improve reliability, reduce maintenance and conserve power**
- **Use multiple technologies for Remote Indication to the Control room to maximize level indication reliability**
- **Conduct proper maintenance and inspection of these critical instruments**

Summary

Your time and attention to this information is appreciated, along with your contributions to Operator and Plant Safety of Power Boilers

Questions

