PENBERTHY®

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PenTech FAQ # 2 by Gary G. Sanders, Vice President - Engineering

Materials used around and in Magnetic Level Gages:

With consideration for the temperature / pressure / chemical compatibility that a process imposes, glass liquid level gages may be designed using almost any solid material for the chamber. The material's remaining requirement is that it not be porous. The Magnetic Level Gage has the same requirements plus one. Materials of construction may **NOT** be magnetic in any form: ferromagnetic (either hard or soft), ferrimagnetic or paramagnetic - hereinafter collectively called magnetic materials.

Background Information

Like all permanent magnets the magnet carried by the float in a magnetic level gage establishes a field of magnetic lines of flux around itself. These magnetic lines of flux are by convention considered to exit the north pole and return to the south pole. Most people have observed these flux lines in high school with the classic 'iron filings on paper over a permanent magnet' demonstration. When these flux lines are close together (e.g., near the poles [usually ends] of the magnet) magnetic force is high. When the lines start to separate (increasing distance from the magnet) the magnetic force is reduced following the inverse square law of field loss. This normal magnetic field tends to be regular, symmetrical and spreads out into space until it is influenced by another magnet or by a magnetic material.

Magnet to magnet

When the flux fields of two magnets intersect in space both fields are distorted. The form of the distortion depends upon whether the flux fields are oriented to align or repel each other. This is classic magnetic coupling and is commonly referred to as "like poles repel, unlike poles attract". This principle is a primary part of the design of visual indicators (yes, they do contain magnets), switches and some transmitters.

Magnet with other materials

Some elemental metals (esp., iron, nickel and cobalt), alloys and ceramics containing ferrite have the ability to provide a low resistance path to magnetic lines of flux compared to air. A basic law of nature states that things tend to take the path of least resistance (know anyone that follows that law?). If materials like these are placed into a magnetic flux field, the lines of flux will tend to pass through (funnel into) the material rather than continue past it. This is the essence of magnetic material attraction - that 'tug' that occurs when magnetic material is close to a magnet. The more lines of flux captured by the material, the stronger the attraction. Remember from high school science horseshoe magnets that had a 'keeper bar' placed on it when not in use? It is used to shunt the flux field directly from pole to pole thereby containing the magnetic field so it does not damage materials placed close to the magnet (think of a floppy disk). It also aids in the preservation of the magnetic strength of the magnet.

Herein lies a potential problem for magnetic level gages. If a magnetic material is brought into the float's magnetic field - the flux lines will shunt though the material. Consider a float inside an A.S.T.M. A106 carbon steel pipe - no lines of flux can extend to the outside of the pipe and reach external devices (visual indicators, switches, transmitters) and, of course, the gage does not work. In fact, the float will tend to 'stick' in some position since the magnetic force is greater than the buoyant force. What is less obvious is the use of magnetic materials (think common irons and steels) in proximity to a magnetic level gage; e.g., flanges, support elements, close pipe runs, vessel shells, steel flooring and ladders, etc.

It is Penberthy's recommendation that all magnetic materials be kept at least 8" [200mm] from the standpipe centerline (6.5" [165mm] from surface) for the standard gage and 5" [125mm] (4.25" [105mm] from surface) for the mini magnetic level gage.

<u>Magnetic materials</u>
What exactly are those magnetic materials that were mentioned at the start of this discussion? While not a comprehensive listing, some commonly encountered examples follow:

<u>Ferromagnetic</u>
These are generally the irons/steels that a metallurgist would call ferritic (α) or martensitic:
    low and high carbon, alloy, tool, silicon and
    many stainlesses (essentially the entire 400 series).
Some nickel alloys; especially those with very high nickel content
Less obvious are the duplex steels which by definition are ≈ 50% ferritic.
    312 (as DP-3); 315 (a.k.a. 3RE60); 318 (a.k.a. 2205); 322 (a.k.a. HiN 2205);
    323 to 325; 327 (a.k.a. Zeron 100); 329 (a.k.a. 7-Mo+); 392; 395
Even less obvious are some forms of rust (think of audio and video tape, floppy and hard disks) and liquefied hydrogen.

<u>Ferrimagnetic</u>
This class includes the ceramics containing ferrite. Common examples are loudspeaker magnets, some dc motor magnets and the magnetoelastomers, i.e., flexible 'refrigerator magnets'.

<u>Paramagnetic</u>
One example will be included in this class - Monel, but only when at or below ≈ room temperature generally precluding it's use in cryogenic processes.

A quick, although not definitive test is to place a small bar magnet on the questionable metallic surface, if it does NOT stick, the material *MAY* be suitable.

<u>Non-magnetic materials</u>
On the other hand, stainless steels which are austenitic (γ) will NOT shunt lines of flux, some common examples are (using familiar terminology):
    Cr-Mn-Ni stainlesses (most of the 200 series); 301 to 310; 312 (as 254 SMO);
    312 to 314; 316 to 317; 319 to 321; 326 (a.k.a. 654 SMO a.k.a. SX); 332; 345; 347; 348
Some nickel based alloys in this group are the Incoloys, Inconels, Hastelloys and 20Cb3.
Polymers, FRP's, etc. belong in this category.

One final side note: When some types of austenitic stainless steels are welded - a small percentage of the austenite is converted to ferrite structures which tends to make the weld area (HAZ) slightly magnetic.