Packing, Linings

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Introduction to Packing

There are two types of packing used in packed towers:

- Packing that is chemically suitable to perform a mass transfer operation (e.g., activated alumina for desulfurization or desiccation.

- Packing constructed of inert material to provide surface area for mass transfer.

Inert packing is most commonly used since it can be utilized repeatedly without significant deterioration. The majority of inert packings used are of the ring or saddle type.

Ring packings are commonly made of metal or plastic except for Raschig rings, which are generally ceramic. Ring packings are used mostly in distillation because of their excellent turndown properties and availability in press-formed metals of all types. Usually ring-type packings are used in handling organic materials when there are no major corrosion problems. Unfortunately rings do not promote most redistribution of liquids, and the Raschig ring occasionally promote liquid maldistribution.

Saddle type packings are commonly made from ceramic or plastic, seldom from metal. Saddles are used largely in absorption and regeneration operations because they provide good liquid redistribution and are available in ceramic and plastic, which yield good corrosion resistance at very low cost. Saddles are usually used for aqueous systems when corrosion is a major factor.

Qualities that are desirable in the selection of tower packings are:

1. High percentage of void space.
2. Irregularity of shape to prevent pattern packing.
3. Low resistance to material flow (low pressure drop).
4. Large active surface exposed per unit volume (high surface area per cubic foot/meter).
5. Complete utilization of surface for mass transfer.
6. Suitably shaped to produce turbulent contact between phases.
7. Large number of interstitial transfer points per unit volume.
8. Good internal liquid distribution characteristics.
9. Wide operating range with little efficiency variation.
10. Mechanically strong to withstand normal loads in service and physical handling.
11. Minimum weight and low side thrust on the tower shell.
13. Minimum investment per year of service life.
14. Clean design to minimize stagnant area and fouling.
15. Capable of easy removal from tower and cleaning.

The packing factor, F, is a standard parameter that provides a capacity rating for packings, by correlation of pressure drop versus gas flow rate through the packing. It represents a ratio of a specific packing surface to the bed voidage space in the packed bed. Low packing factors are desirable.

Size 3: 1.0CPR, 0.5PPR, 1.0PPR, 1.5PPR, 2.0PPR

The Pall ring is especially useful for distillation operations at any pressure. The Pall ring is also used in absorption and stripping operations, particularly in high pressure absorbers with small diameter shells where the ability to handle high liquid and gas rates allow for major cost savings.

Pall rings are Raschig rings that have their wall opened with the projections bent inward, permitting complete access to the interior for both gas and liquid flow. This design makes possible greater capacity, lower pressure drop, high gas and liquid rates, greater efficiency, better maintenance of distribution, lower liquid hold-up and less entrainment than the conventional Raschig ring. Pall rings are available in carbon steel, stainless steel, aluminum alloys, copper, monel, nickel and inconel. Plastic Pall rings are available in polypropylene, glass reinforced polypropylene and halar. Diameter sizes range from 0.5 to 2.0 INCHES.
Raschig rings, perhaps the most commonly used packing, are useful in distillation, absorption and stripping operations. They provide increasing efficiency as loading increases to the point of incipient flooding, beyond which their operation becomes unstable. They are not suggested for use when high efficiencies are required or when liquid loading approaches flooding.

Raschig rings are small hollow cylinders. They are the least efficient inert packing available because their construction does not promote much liquid distribution, occasionally may promote liquid maldistribution, lends itself to pattern packing, and does not provide much turbulent contact between phases. They are available in carbon steel, stainless steels, stoneware, porcelain, karbate and plastics. Diameter sizes range from 1.0 to 3.0 INCHES.

There are widely used in the manufacturing of sulfuric acid, CO₂ absorption in the pulp and paper industry, cooling and drying of chlorine and removal of noxious fumes in many industries.

The Intalox saddle is a packing that offers large total surface area per cubic foot, minimum resistance to liquid and gas flow, high percentage of void space, a low packing factor, excellent liquid distribution, maximum randomness and high efficiency with a large capacity in mass transfer operations. These qualities make Intalox saddles especially effective in distribution and absorption operations. Saddles are available in ceramics and plastics. Ceramics are chemical stoneware and chemical porcelain, of which chemical porcelain is preferred since it is mechanically stronger, non-porous, iron-free and inert to chemical attack. Plastic saddles are available in polypropylene, linear polyethylene, rigid PVC, CPVC, glass reinforced polypropylene, kynar and halar. Diameter sizes range from 0.25 to 3.0 INCHES.

These items are used with slightly less efficiency than Intalox saddles for distillation, stripping and absorption operations.

A Berl saddle is a negatively warped surface resembling a saddle. Berl saddles have one shortcoming. Their efficiency changes with changes in loading. As loading approaches flooding, mass transfer becomes unstable and unpredictable. However, they do promote good liquid distribution, have a high percentage of void space and provide a large surface area for mass transfer. They are available in stoneware, porcelain, ceramics, plastics, stainless steel, carbon steel and in karbate. Diameter sizes range from 0.5 to 1.5 INCHES.

Activated aluminas are used for desiccation of liquids and gasses, desulfurization, catalytic applications and as scavengers for various contaminants such as fluorides.

Activated aluminas are manufactured in granular and ball forms as crystals and gels. They are highly porous and inert.
Activated carbon is effectively and economically utilized in decolorization, odor removal, solvent recovery, refining gasses and liquids, catalysts and adsorption. Its major uses are in solution purification, such as the clean-up of cane, beet and corn sugar solutions, and for the removal of tastes and odors from water supplies, vegetable and animal fats and oils, alcoholic beverages, chemicals and pharmaceuticals. Also commonly used in the recovery of gasoline from natural gas, recovery of benzol from manufactured gas and the recovery of solvents vaporized in industrial processes such as the manufacture of rayon, rubber products, film and plastics. Other common uses are removing impurities from gases such as hydrogen, nitrogen, helium, ammonia, and CO₂ and removing organic sulfur compounds, H₂S, and other impurities (Fe, Cu) from manufactured and synthesis gases.

Activated carbons can be divided into two main classes:

- Those used for adsorption of gases and vapors, for which a granular material, providing great surface area and pore volume is generally employed.
- Those used in purification of liquid, for which a powdered material is desired.

Many carbonaceous materials treated with oxidizing gases (e.g., coal, lignite, sawdust) may be used for the manufacture of activated carbon depending on its desired application. Activation is a physical change where the surface of the carbon is greatly increased by the removal of hydrocarbons.

**Introduction to Lining**

A lining is material that lines the inside surface of a tank, tower, furnace, or other piece of process equipment and protects that piece of equipment from destruction by high temperature, corrosion or abrasion. Some of the common lining types follow.

**Acid Brick**

These linings are used in Acid Service (pH less than 4.5) to protect a membrane coating from deterioration due to abrasion or high temperature (T greater than 150 DEG F). Red Shale Brick (RSB) is the cheapest and can be used in low temperature service. When a more refractory material is desired, acid resistant fireclay (30% alumina) is used.

Acid brick can be installed with two different mortars. Silica mortar is more economical but can not be used in all applications. Furfural based mortar is more expensive but is resistant to a wider range of materials.

**Castable Refractories and Gunning Mixes**

These materials can be installed in varying thicknesses. For thicknesses greater than 4 INCHES, it is necessary to use anchors to hold the refractory to the metal surface. Gunning mixes have higher material costs and lower labor cost than castables; thus, installed costs of the two are approximately equal.

Fifty percent alumina gunning mix is useful in services involving severe abrasion, reducing atmospheres and moderate temperatures. Typical applications are cyclones, fluid catalytic cracking, naphtha reforming and coking.

Ninety percent alumina castable and 90% alumina gunning mix are useful for applications with temperatures higher than 50% alumina gunning mixes.

**Fluorocarbon Linings**

Fluorocarbon linings are resistant to a wide variety of corrosive chemicals at temperatures up to 180 DEG F. The most common fluorocarbon linings are Teflon™ and Kynar™.
Glass Linings

Glass linings are shop installed and are all satisfactory for a wide range of corrosive services at temperatures up to 450 DEG F.

Refractory Brick

These linings are used in high temperature service. Selection of the type brick to be used is a function of the process temperature, expected degree of chemical attack and expected degree of abrasion.

Insulating firebrick has lower thermal conductivity and heat capacity than refractory firebrick. It is generally used as a backing for refractory firebrick. Since it is relatively non-resistant to chemical attack and abrasion, it is used as the inner lining only when no erosion or abrasion is expected. Insulating firebrick is ASTM Group 26 material (good to 2,600 DEG F).

Sixty percent alumina firebrick is a high alumina refractory useful for operating conditions involving thermal cycling and chemical attack. Sulfuric acid processing and spent acid regeneration are two applications for this material.

Ninety percent alumina firebrick is a high alumina refractory useful in operating conditions involving thermal shock, slagging, corrosion and high temperatures. Typical applications for this material are hydrotreating and sulfur burners.

Resin Linings

Resin linings are used in a variety of corrosive services at operating temperatures up to 250 DEG F. These linings offer good solvent resistance. Some common resin linings are asphaltic resin, epoxy resin and phenolic resin. Resin linings may be applied by spray gun, brush or roller.

Rubber Linings

These linings are satisfactory in a wide range of corrosive services at temperatures less than 150 DEG F. Rubber linings are almost always applied in the vendors shop. The most common rubber linings are butyl rubber, natural rubber and neoprene.

Lead Linings

Lead sheet was used extensively in the manufacture of sulfuric acid. Today, new process technology has nearly eliminated the use of lead as a lining material.

Zinc Linings

Zinc is frequently applied to water tanks for cathodic protection. The zinc can be flame sprayed (also called metallizing) or painted onto the carbon steel base material. Flame spraying is the process whereby metallic zinc is vaporized in a flame and sprayed onto the steel base material. The hot zinc does not merely coat the carbon steel, it forms an alloy with the steel several mils deep.

Zinc can also be supported in an epoxy base paint and brushed, rolled or sprayed onto the steel.
# Packing, Linings (PAK, LIN)

See Material Selections chapter for a complete list.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety of vessel packing materials including rings, saddles and other formed shapes, crushed materials, adsorbents, resins, etc.</td>
<td>PACKING</td>
</tr>
</tbody>
</table>

**Packing Type:** See Chapter 28 for packing materials.

Brick and mortar for acid service applied to protect a membrane coating from deterioration under abrasive or high pressure service.

**Material Selection:** Default: *25RSB*
- 25RSB - 2.5 INCHES [62 MM] red shale
- 45RSB - 4.5 FINCHES [112 MM] red shale
- 80RSB - 8.0 INCHES [200 MM] red shale
- 25AFC - 2.5 INCHES [62 MM] Al f-clay
- 45AFC - 4.5 INCHES [112 MM] Al fclay
- 90AFC - 9.0 INCHES [225 MM] Al fclay

**Mortar Type:** Default: *FUR*  
- FUR - Furfural base mortar  
- SIL - Silicone base mortar

**Lining Adjustment:** See “Suggested Lining Difficulty Adjustment.” Range: 1 - 10; Default: *4*

Castable refractory or gunned mixes.

**Material Selection:** Default: *GUNIT*
- GUNIT - Gunite on wire mesh
- GUNA5 - Gunn. 50% Al anchored
- GUNA9 - Gunn. 90% Al anchored
- CASA9 - Cast. 90% Al anchored
- GUN50 - Gunn. 50% Al no anchor
- GUN90 - Gunn. 90% Al no anchor
- CAS90 - Cast. 90% Al no anchor

**Lining Thickness:** Max: 9 INCHES [225 MM]; Default: 4 INCHES [100 MM]

**Lining Adjustment:** See “Suggested Lining Difficulty Adjustment.” Range: 1 - 10; Default: *4*

Brick: 60%, 90% alumina firebrick, insulating firebrick; abrasion resistant, replaceable linings: ceramic, rubber, steel, alloy; coatings: organic, glass and metallic.

**Material Selection:** See Chapter 28 for lining materials.
- Default: *EPLCS*

**Lining Adjustment:** See “Suggested Lining Difficulty Adjustment.” Range: 1 - 10; Default: *4*
## Suggested Lining Difficulty Adjustments

<table>
<thead>
<tr>
<th>Work Item</th>
<th>Difficulty Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lining a straight tank</td>
<td>1</td>
</tr>
<tr>
<td>Typical lining</td>
<td>4</td>
</tr>
<tr>
<td>Lining a large horizontal vessel (&gt;5000 GALLON [19 M3] capacity)</td>
<td>6</td>
</tr>
<tr>
<td>Lining a small horizontal vessel (&lt;5000 GALLON [19 M3] capacity)</td>
<td>8</td>
</tr>
<tr>
<td>Small, obstructed area</td>
<td>10</td>
</tr>
</tbody>
</table>