Department of Chemical Engineering

Institute of Engineering & Science

IPS Academy

Annual Magazine 2017- 18

B'Reactive

Dear Faculty members and friends

In continuation of our endeavors to inform, educate as well as provide an opportunity to deserving people.

This edition of Magazine '**B Reactive'** embodies myriad of articles from Chemical Engineering department IES-IPS. Newsletter through this edition attempts to diversify by dealing with various questions relating to chemical engineering, in the form of surveys which point to the general perception of people regarding these matters. Besides that it doesn't forget its primary objective that is to promote chemical engineering from its grass root levels.

We hope that this edition would be enjoyable as well as informative.

Editors...

Words from the desk of HOD

This decade is a time of unparalleled growth and change for India, with the opening up of the frontiers of the world through globalization, there is a need for efficient competence in the global scenario. This need for competence is what that drives our Department to strive for the pinnacle of success. Since its inception in the year 2004, the Department has always strived to create a cadre of professionals who are technically and professionally proficient.

The Department prides itself on preparing the students for creative careers in industries, academia and Government agencies. 350 numbers of students have successfully graduated and are catering to the needs of society.Our accomplished courses and adept faculties not only endeavor to cover the complete syllabus but to motivate students to learn beyond the syllabus which definitely develops complete knowledge of the subject (practical and theoretical) and develop skill sets of students to become promising engineers in future.

As per the need of current growing trend, the department have initiated post-graduation course from 2011 in Chemical Engineering with specialization “Computer Aided Chemical Process Plant Design”. The Department has been successfully carrying out testing & IEDC projects over last two years.

Prof. Rajesh Kaushal
Head, Chemical Engineering
IPS Academy, IES

Message from the Principal

Technical Education is the most potential instrument for socio-economic change. Presently, the engineer is seen as a high-tech player in the global market. Distinct separation is visible in our education between concepts and applications. Most areas of technology now change so rapidly that there is a need for professional institutes to update the knowledge and competence.

Institute of Engineering and Science, IPS Academy is a leading, premium institution devoted to imparting quality engineering education since 1999. The sustained growth with constant academic brilliance achieved by IES is due to a greater commitment from management, dynamic leadership of the president, academically distinctive and experienced faculty, disciplined students and service oriented supporting staff.

The Institute is playing a key role in creating and ambiance for the creation of novel ideas, knowledge, and graduates who will be the leaders of tomorrow. The Institute is convinced that in order to achieve this objective, we will need to pursue a strategy that fosters creativity, supports interdisciplinary research and education. This will also provide the students with an understanding and appreciation not only of the process of knowledge creation, but also of the process by which technology and knowledge may be used to create wealth as well as achieve social economic goals.

I am delighted to note that the engineering graduates of this institute have been able to demonstrate their capable identities in different spheres of life and occupied prestigious position within the country and abroad. The excellence of any institute is a measure of achievements made by the students and faculty.

Dr. Archana Keerti Chowdhary
Principal
IPS Academy, IES

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IIChE STUDENTS' CHAPTER

EDITORIAL BOARD (2017-18)

Content

Advancing with Automation

Many, if not most, of us have heard of the Industrial Internet of Things (IIoT). Simply stated, it refers to the manufacturing application of the Internet of Things, or the interconnectedness of "smart" machines. Similar to what we see with the rapid advances to our personal devices, such as smart phones, smart cars, smart televisions and more, smart devices in industrial settings offer the ability to move to new manufacturing strategies.

A number of the new technologies that are enabling the IIoT include mobile devices, self-learning machines, drones, 3-D visualization, cloud applications and more. At the recent ARC Industry Forum, "Industry in Transition: Navigating the New Age of Innovation" (February 8–11; Orlando, Fla.), Andy Chatha, president of ARC, suggested that more "connected" products are and will continue to be available for the production environment. Just as an automobile company can monitor cars in the field, he envisions that industrial machine manufacturers would be able to monitor their equipment (pumps, for example) over the lifetime of the asset. Chatha expects that the "cloud connected plant is at hand," with connected machines, supply chains and workers. Designing for connectivity, however, needs to be done from the start.

A Significant Step toward a New Process-Automation System

Cyber security and open platforms for interconnectivity are important challenges for advances in process automation. Lockheed Martin (Bethesda, Md.; www.lockheedmartin.com) was recently contracted by ExxonMobil Research and Engineering Company (EMRE) to develop a "next-generation" open automation system for process industries. According to EMRE's vice president of R&D, Vijay Swarup, "This breakthrough initiative could help transform refining and chemical manufacturing through the use of high-speed computational components, modular software, open standards and the use of autonomous tools." The intention is to design the platform with intrinsic cyber security protection that can be adapted to emerging threats. This development represents a new approach to process automation.

Training with New Technology

One way in which technology can enhance manufacturing procedures is through training programs with advanced simulators. While there is much going on with 3-D immersive simulators for training, advanced screen simulators can address a number of the challenges facing today's plants, such as engaging new operators in a familiar "game-like" environment, providing realistic "hands-on" training and preparing operators to respond to unplanned events. Simulators can help, for example, to manage alarms (see our two-part feature on alarm management in this issue, pp. 50–60). At the ARC Forum, Ron Cisco, O&M supervisor IV with the Salt River Project – Coronado Generating Station, gave an insightful presentation on how use of a modern-day simulator resulted in an "observable increase in confidence and knowledge levels of trainees."

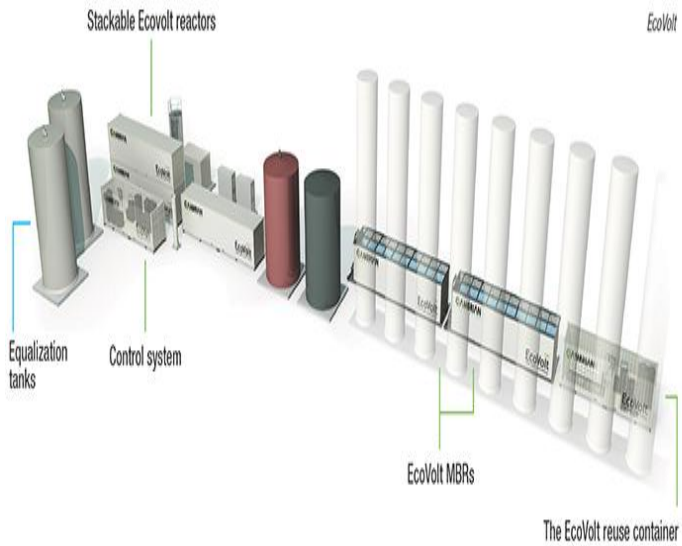
Keeping up-to-date with the latest technologies in process automation is increasingly important for the chemical process industries (CPI), as the advances are coming quickly and can bring significant changes to the way manufacturing plants operate. While caution in implementing new systems is warranted, the new technologies offer a wide breadth of new possibilities.

Ayush Pandey **(Final Year)**

Bioelectrochemical System Treats Wastewater and Generates Biogas

The first full-scale installation of a unique Bioelectrochemical wastewater-treatment system was recently started up at a California brewery. The system, known as the EcoVolt Reactor, was developed by Cambrian Innovation Inc. (Boston, Mass.; www.cambrianinnovation.com). EcoVolt Reactor is a microbial reactor system that eliminates around 90% of biological oxygen demand (BOD) in wastewater while generating methane from the organic carbon.

The EcoVolt Reactor system works by applying a small electric current to an electrochemical cell containing naturally occurring bacteria species. The applied current activates metabolic reaction pathways that would not be possible in normal anaerobic microbial respiration. The anaerobic microbes are grown on a fixed film that is designed for enhanced stability, says Justin Buck, co-founder and chief technology officer at Cambrian. The system is related to a microbial fuel cell, Buck explains, but instead of generating a current from the biological redox reactions, a small current is added to stimulate desired anaerobic respiration pathways and products. The current also provides continuous feedback in real time, allowing the system to monitor itself.



The initial EcoVolt Reactor installation treats high-BOD spent brewery water at a California craft beer facility, producing enough biogas to generate 130 kW of renewable electricity and 45,000 therms of heat per year in a combined heat and power (CHP) system. Downstream polishing units (EcoVolt MBRs — aerobic membrane bioreactors) remove the remaining BOD and trace solids, producing clear, reusable water (80,000 gal/d). The EcoVolt system allows the brewery to cut its water footprint by 40% while producing more than 20% of its energy demand.

The EcoVolt Reactors are modular, railcar-sized units that are road-transportable and fully automated, so capacity can be expanded by adding units, Buck says. Cambrian is looking for its first applications in the beer and wine-making space because the wastewater from those processes disrupts municipal water treatment systems and comes with significant expense to producers, Buck says. It may expand to other applications in the future.

Ashu Agrawal (Final Year)

Nalco Becomes Nalco Water

A global leader in water, hygiene and energy technologies and services, has changed the name of Nalco its water and process services business to Nalco Water (nalco.ecolab.com). The new name more clearly communicates Nalco's water-management expertise, as water scarcity is becoming a major global challenge and an increasing constraint to business growth.

"Nalco Water brings unparalleled water management expertise to customers around the world," says Christophe Beck, Ecolab executive vice president and president of Nalco Water. "Water is integral to our customers' key processes, and as demands on the world's limited fresh water resources increase, Nalco Water's role in helping customers enhance productivity and improve product quality while using less water and energy will be more important than ever."

Nalco Water provides water and process services to customers in a range of industries including food and beverage, buildings and institutions, manufacturing, paper, power, primary metals, chemicals and mining.

Nalco Water will continue to deliver total water management solutions through a comprehensive approach that minimizes water use to maximize operational performance at optimized cost. The company offers industry-leading solutions such as 3D TRASAR Automation Technology to meet the complex water management needs of its customers.

"The demand for fresh water is expected to grow by 40% by 2030, placing pressure on businesses to rethink how they manage their water," Beck says. "To address these challenges, businesses around the world are setting ambitious water goals. Nalco Water and Ecolab are partnering with those businesses to reduce, reuse and recycle water to help achieve their goals and preserve natural resources."

Nalco Water, which is headquartered in Naperville, Ill., merged with Ecolab in 2011. The name change will not affect Nalco Champion, Ecolab's energy services business.

Azaz Reshamwala (Final Year)

Reliable Operation and Sealing of Agitators

Mechanical seals, as required by most vessel agitators, are systems sufficiently complex to warrant a good understanding by engineers and appropriate training for operators

To ensure safe and reliable agitator operation, the sealing of the rotating shaft is of fundamental importance. Depending on the operating conditions such as pressure, temperature and speed various sealing principles may be used. A comparison of their characteristics with the requirements for mixing shows that mechanical seal technology offers many advantages over other sealing methods. In particular, when hazardous substances are being mixed or an explosive atmosphere is present, the use of a mechanical sealing system is almost mandatory, especially if the mixing vessel operates at elevated pressure and temperature.

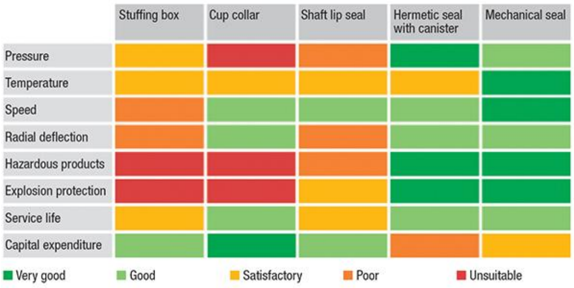
Agitator Seal Systems Compared

A reliable mechanical design for an agitator (Figure 1) must take into account the hydraulic loads on the impellers, which in turn create the torques and bending moments that exert mechanical loads on agitator components such as the shaft, bearing and gearbox. Secondary loads, such as oscillations, vibrations and noise emissions also play important roles.

Shaft seals can be divided into two main groups: radial and axial seals. The main difference between these two groups is the direction in which the contact forces act.

Typical types of radial shaft seals include radial sealing rings, lip seals and stuffing boxes. Here, the sealing effect is provided by radial forces, and the length of the cylindrical sealing gap is in the axial direction. Although radial seals are relatively insensitive to axial displacement, radial shaft deflections lead to higher sealing forces on one side, which may cause leakage and accelerate wear.

In contrast, the sealing forces in axial shaft seals act in the axial direction. This results in a horizontal sealing surface with a concentric circular cross-section. Owing to their design, axial shaft seals are relatively insensitive to radial shaft deflections and are thus very suitable for agitator applications. Axial displacements have to be compensated with elastic elements. Mechanical seals belong to the group of axial shaft seals. Below, some examples of each type of seal are discussed in more detail

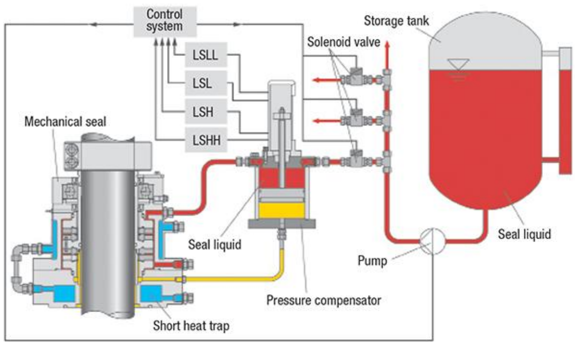


Stuffing boxes Historically, stuffing-box packings are the oldest type of sealing element. The term “stuffing box” originates from early steam ship construction. The passage for the shaft through the hull was sealed with oil-soaked rags that were stuffed into the gap between the shaft tube and the housing. The first mixing vessels were often equipped with a stuffing box.

Lip seals In mixing applications, the working principle of lip seals can be in either the radial or the axial direction. Cup collars, which provide axial sealing, can be shifted to different positions along the shaft. A cup collar whose lip runs along the surface of the mounting flange can protect surrounding equipment from steam or other vapors inside the mixing vessel, though it works only for vessels operating at atmospheric pressure. Radially acting lips — usually made from a modified polytetrafluoroethylene (PTFE) material — are also used to seal mixing vessels. These shaft lip seals, however, must be equipped with relatively complicated bearings to limit shaft deflections within the seal housing to about 0.01 mm. This is the only way to operate the lips reliably at pressures of up to 6 bars.

Hermetic seals To hermetically seal a mixing vessel using only static seals, the mechanical energy required at the impellers must be transmitted through the wall of the closed vessel. The input torque of a magnetic drive is transmitted to the shaft through a canister using permanent magnets.

Mechanical seals Mechanical seals with dynamic sealing elements are regarded as technically tight when pressurization of the seal liquid is able to maintain a positive pressure gradient between the seal liquid chamber of the mechanical seal and the product in the vessel. Most mechanical seals used with agitators have two pairs of sealing rings: two rotating and two stationary rings (Figure 3). These pairs of rings form an enclosed space — the seal chamber — that can be filled with seal liquid. The contents of the vessel can be reliably sealed against the surroundings by applying pressure to the seal liquid.



If the seal-chamber pressure is controlled so that it is always higher than that inside the vessel, the product inside the vessel cannot get past the mechanical seal. However, the unavoidable leakage of seal liquid past the inboard sealing rings will enter the vessel, while leakage past the outboard pair of sealing rings will enter the surroundings.

The design principles of mechanical seals can be divided into single- and double-acting seals. Another differentiating feature is the type of seal-ring lubrication: dry-running, gas-lubricated or liquid-lubricated.

Single-acting mechanical seals The key design feature of single-acting mechanical seals is that they have only two seal rings. This means they have only one interface and no seal-liquid chamber. A key characteristic of single-acting mechanical seals is that they can leak into the surroundings of the vessel. The leakage rates are generally not high: about 10–100 mL/hr of gas for dry-running seals and 10–50 mL/d of liquid for side-entry mechanical seals. This means that the vessel is not technically tight, in contrast to double-acting mechanical seals. Therefore, this seal design cannot be used when hazardous materials are to be mixed.

Although dry-running mechanical seals do not need seal-liquid supply systems and their corresponding monitoring devices, the seal rings are subject to relatively high wear. The service life is therefore much lower than that for liquid-lubricated mechanical seals. Nevertheless, dry-running mechanical seals can achieve service lives of a year or more under appropriate operating conditions.

Liquid-lubricated single-acting mechanical seals can achieve much longer service lives, where the nature of the product allows them to be used. Many applications involve suspended solid particles that — depending on their hardness and particle-size distribution — can greatly influence the service life of the seal rings. These seals are generally equipped with two seal rings made from abrasion-resistant silicon carbide (SiC). However, the use of two hard materials is not ideal with respect to sliding friction. In this case, it is usually better to use a softer material for one of the faces, accepting higher wear in return for lower friction.

Double-acting mechanical seals Double-acting liquid-lubricated mechanical seals are the most common type for mixing applications, where they can be used under nearly all operating conditions. They are also available in gas-lubricated variants, in which a continuous supply of gas into the seal chamber maintains a seal gap of a few micrometers, thus preventing wear of the seal rings. The characteristic feature of a double-acting mechanical seal is its seal-fluid chamber that can be filled with seal liquid or gas, thus separating the interior of the vessel from its surroundings.

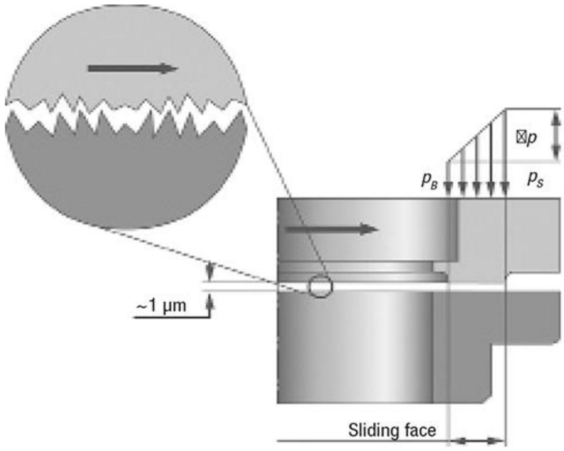
Figure 2 shows how the various types of seals discussed above score against process parameters such as temperature and pressure, plus broader criteria like cost and service life. It is obvious that mechanical seals offer many advantages over the other types. Particularly if hazardous or explosive materials are being mixed, a mechanical seal is practically mandatory. A hermetic seal with a canister in combination with a mechanical seal is used for applications requiring the highest safety, such as hydrogenation or phosgenation reactions.

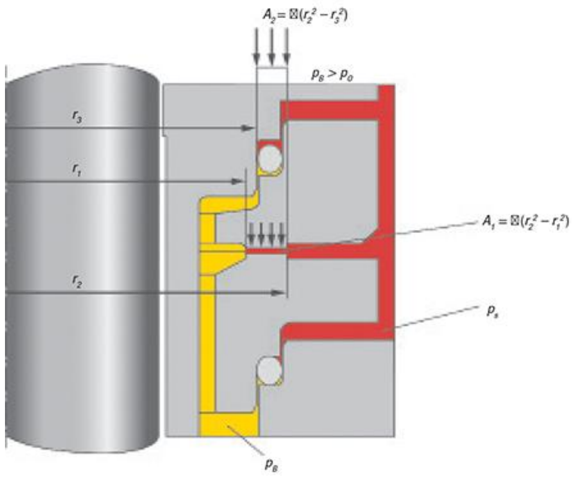
Basics of Mechanical Seals

A mechanical seal system, as shown in Figure 3, has several components. Alongside the mechanical seal cartridge itself are the hydraulic components (such as a pressure compensator), and the rest of the installation, comprising the pipework, instrumentation and mountings. Some applications also include a seal-liquid refilling system. As a consequence, in most mixing systems, reliable sealing depends on the complete mechanical seal system. Careful selection of suitable hydraulics and installation components is just as important as the design of the mechanical seal itself.

The function of a mechanical seal is essentially governed by the mechanisms taking place in the gap between the rotating and the stationary seal rings. As Figure 4 shows, the seal interface can be imagined as a very narrow annular gap across which the seal faces are in partial contact. Full solid contact would be ideal from the perspective of avoiding leakage. On the other hand, a pure fluid film — with no solid contact — minimizes frictional forces, wear and heat generation. The design of the seal ring must therefore take into account both aspects, and thus always represents a compromise. This condition is known as mixed friction: the seal faces are in partial contact, yet thanks to lubrication they also are able to slide over each other.

The physical and chemical processes taking place within the sealing gap of a mechanical seal are difficult to describe theoretically. Some processes, such as blistering on seal faces, are not yet completely understood because it is hard to take measurements at the seal interface. The key variables influencing the sealing and frictional characteristics of seal rings are the various axial forces, which operate in both the opening and closing directions. As Figure 4 shows, the pressure between the seal faces pushes the seal rings apart, whereas the hydraulic pressure on the rings (Figure 5) pushes them together. The ratio of these forces governs the efficiency of the sealing function and how easily the seal rotates. The closing forces must be slightly higher than the opening forces; otherwise, there is a risk that the gap will open suddenly and the seal will start to leak.





The ratio between the closing forces and the opening forces is described mathematically by the hydraulic balance ratio K (Figure 5):

$$K = \frac{\text{hydraulic loading area}}{\text{sealing interface area}} = \frac{A_2}{A_1} \quad (1)$$

With the assumption of a linear pressure drop across the sealing interface (Figure 4), the closing and opening forces will balance when K = 0.5. In practice, optimum performance is obtained when the value of K lies between 0.6 and 0.9. The hydraulic balance ratio K is also used to characterize mechanical seals as unbalanced or balanced. Unbalanced mechanical seals have K > 1, whereas balanced seals have K < 1. Unbalanced seals are expedient for simple operating conditions, such as low pressures and low agitator speeds. Here, the high hydraulic balance ratio, with closing forces dominant, provides good sealing efficiency without thermally overloading the mechanical seal. In more-difficult operating conditions, such as high pressures and high agitator speeds, only balanced mechanical seals can be used.

So far we have ignored the closing force contributed by the springs that form part of every mechanical seal. This force is generally equivalent to a pressure of 1–2 bars. This is important at low operating pressures, but can confidently be neglected at vessel pressures above 10 bars. Nevertheless, even high-pressure mechanical seals require springs to keep them closed while they are unpressurized.

Barrier Fluids

Another essential factor influencing the function of a mechanical seal is the choice of barrier fluid. This liquid has three main functions: lubrication, cooling and sealing. It must also meet certain secondary conditions, such as compatibility with the product and, if necessary, conformity with the specifications of the U.S. Food and Drug Administration (FDA).

Figure 6 compares barrier fluids used in mixing applications with respect to their suitability for various tasks. It is clear that the demands of lubrication and cooling may conflict. Water cools efficiently, but lubricates poorly, whereas the reverse is true for mineral oils and pure glycerin. A mixture of glycerin and water can be a successful compromise: the glycerin lubricates, while the water phase cools. For this reason, glycerin/water mixtures should always be used if possible. Unfortunately, not all products tolerate a glycerin in-leakage of several milliliters per day, though it is technically possible to collect the leaked barrier fluid and keep it away from the product.

Especially when water or organic solvents are used as barrier fluids, special cooling measures may be necessary to dissipate the greater frictional heat. Compromises of this kind in the choice of barrier fluid generally shorten the service life of the seal rings.

Materials of Construction

Modern seal rings made of Si, graphite, or Si/carbon graphite composites can handle nearly all sealing tasks. O-rings are nearly always made of fluorocarbon (FKM/FPM) rubber such as Viton, which withstands a wide range of temperatures and chemical environments. The most demanding requirements for chemical resistance require perfluoroelastomers (FFKM). Most of the other components of mechanical seals are made of stainless steel.

Supply Systems

Supply systems ensure that the mechanical seal operates safely and reliably. A mechanical seal is regarded as being technically tight when the pressure in the seal chamber is always higher than the vessel pressure. The supply of seal liquid is thus of primary importance to safety. The seal liquid also lubricates the seal interface. The tasks required of the supply system include:

Pressure maintenance Alternatives for pressure maintenance are continuous flow systems and pressure compensator arrangements (discussed further below).

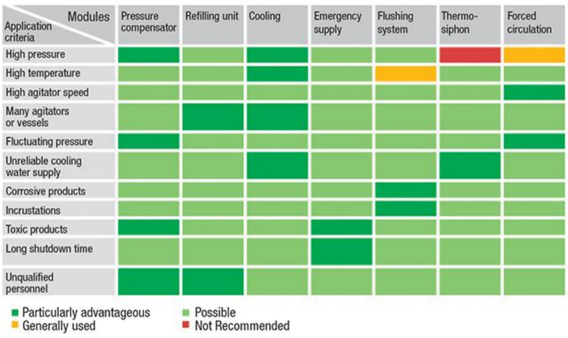
Cooling The physical processes taking place in the seal interface and at the seal faces are very sensitive to high temperatures. If critical values are exceeded, this may cause localized areas to dry out, resulting in hotspots and greater shear stresses on the surfaces of the seal rings. The sealing function is compromised as soon as the surface structure has been destroyed (blistering). Heat conducted to the seal from the vessel, and generated by friction at the seal interface, must therefore be continuously removed. Continuously operating cooling systems are extremely important for reliable operation. Cooling systems for mechanical seals must be designed so that the seal rings, O-rings and barrier fluid are not thermally overloaded. The weakest link in this chain is usually the barrier fluid, because it evaporates if the temperature of the seal faces is too high. Without the cooling and lubrication provided by the barrier fluid, the seal faces will rapidly suffer damage and drastically reduced service life. Long-standing experience at EKATO indicates that, irrespective of the type of barrier fluid, the temperature should not exceed 80°C.

Flushing In many processes, corrosive or abrasive substances contaminate the surfaces of the seal rings. To protect them, the rings can be flushed with a compatible liquid.

Emergency supply In the event of an unexpected increase in the leakage rate due to damaged seal rings, the normal system may not be able to supply enough barrier fluid to keep the seal rings cooled and lubricated. To maintain the positive pressure difference between the mechanical seal and the vessel, and thus maintain the lubrication function, a backup seal liquid (often water) is circulated through the mechanical seal at a higher flowrate. This allows the reactor to continue operating for a certain time after leakage has increased.

Seal liquid refill system An outstanding characteristic of mechanical seals is their very small leakage rate, even at elevated vessel pressures. A leakage rate of only 20–50 mL/d can be expected during normal agitator operation at vessel pressures up to 70 bars. Nevertheless, it is advisable to monitor the leakage rate continuously and refill the system automatically when needed. This is especially important in continuous mixing processes.

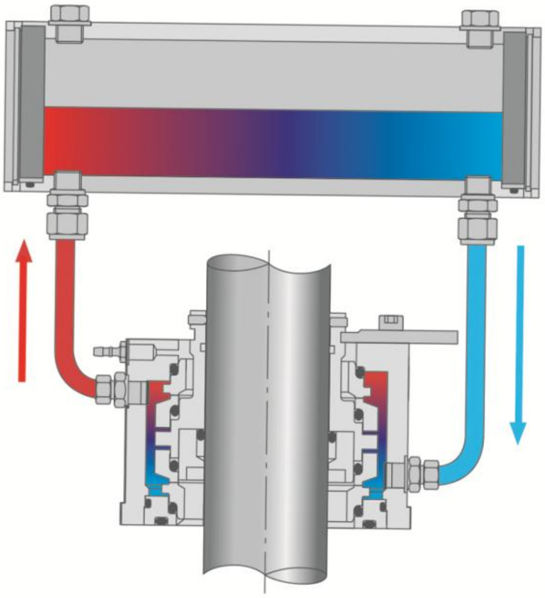
Figure 7 shows the support systems recommended for various operating conditions.



Continuous Flow Systems

Water cooling systems and circulation pumps are not very popular because the necessary pipework and pumps increase the capital outlay. They also consume water and electricity, and require extra maintenance.

Fortunately, simple sealing tasks do not require these additional elements if we exploit the thermosiphon effect to circulate the seal liquid, and natural convection in the surrounding air for cooling (Figure 8). Hot liquid has a lower density than cold liquid, so it rises into a storage vessel mounted above the seal. Natural cooling of the liquid storage vessel then sets up a circulation through the seal. The storage vessel can also be cooled with a water jacket instead of air. A supply of compressed gas is required to pressurize the storage vessel.



If the thermosiphon effect is insufficient to remove the generated heat quickly enough, the seal liquid must be circulated with a pump. Natural convection cooling with air must also be replaced or supplemented by forced cooling with liquid, for instance cooling coils in the storage vessel.

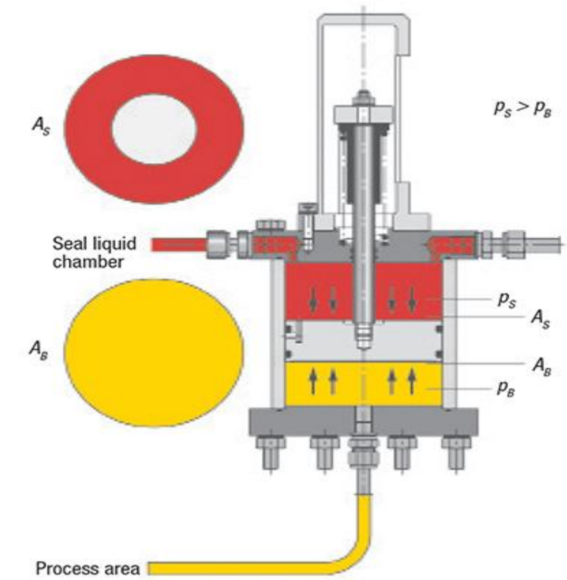
The resulting forced circulation cooling system (Figure 9) can only operate reliably if it is equipped with suitable monitoring instruments, such as flowmeters and temperature sensors. The most important component in terms of safety is the pressure control valve. This ensures that the pressure in the seal-liquid circuit is always greater than the vessel pressure. The usual arrangement is to set the seal-liquid pressure at a fixed value 10% above that of the maximum vessel pressure.

Also important to safety is an accumulator. If the circulation pumps should fail, for instance following a power failure, the high pressure in the seals is maintained by valves. During this time, the accumulator ensures that the pressure in the seal-liquid circuit remains higher than in the vessel, and also supplies more seal liquid to replenish leakage.

Pressure Compensators

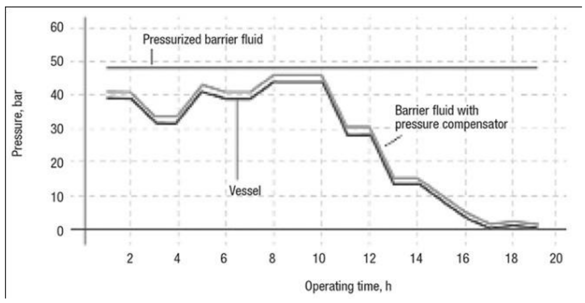
An alternative to setting the seal-liquid pressure at a fixed value is to use a pressure compensator. This allows the seal-liquid pressure to follow the vessel pressure. A pressure compensator is a hydraulic cylinder in which a piston acts as a divider between two fluid chambers (Figure 10). The lower face of the piston is subjected to the vessel pressure p_B, while the seal-liquid pressure p_S acts on the upper face. The area of the lower face (A_B) is shown by the yellow circle in Figure 10; the upper face has a smaller area (A_S) because the piston rod occupies some of the top surface, as the red “dougnut” in Figure 10 shows. The force balance is:

$$p_B \times A_B = p_S \times A_S \quad (2)$$



Because $A_B / A_S > 1$, $p_S > p_B$. The area of the piston rod is arranged so that the pressure in the seal liquid is always higher than the vessel pressure by the required differential.

As Figure 3 shows, the lower chamber of the pressure compensator is connected to the headspace of the vessel via the seal flange. The upper chamber is connected to the seal-liquid chamber. This arrangement ensures that the pressure in the seal-liquid chamber automatically follows the vessel pressure



The inboard pair of seal rings is generally regarded as particularly critical because these rings are directly exposed to the process, and so bear the brunt of corrosion, erosion and high temperatures. Under varying operating conditions, such as those found in batch processes or during commissioning, a pressure compensator can reduce wear on these rings by dropping the seal-liquid pressure to the minimum safe value. Pressure compensator systems are generally equipped with a manually controlled pump for refilling. An automatic refill system is recommended if there is more than one agitator (Figure 12) to exclude possible errors by operating personnel. Position monitoring of the pressure-compensator piston (Figure 3) provides very sensitive monitoring of the leakage behavior of each individual seal. This enables countermeasures to be started in good time if premature failure of the seal is imminent.

SUMMARY

In most mixing systems, reliable agitator sealing requires a complete mechanical sealing system. As well as the mechanical seal itself, auxiliary equipment is needed to maintain an adequate flow of fluid at the correct temperature and pressure to cool and lubricate the seal faces. Careful selection of hydraulic and other components is thus just as important as the reliable design of the mechanical seal itself. The sealing function of the vessel can only be guaranteed and maintained if the complete system is correctly selected, installed and maintained.

When a mixing system is being commissioned, support and training for the equipment operators are very important to allow work to proceed rapidly and without problems. Once the plant is up and running, training and support are often the cornerstones needed to ensure high availability of the complete mixing system.

Harsh Ajmera (Third Year)

Optimizing Pressure Relief Systems

Alternative designs for pressure relief systems may offer investment cost savings

Pressure relief systems for the chemical process industries (CPI) are essential to prevent a process system, or any of its components, from being subjected to pressures that exceed the maximum allowable accumulated pressure, by emergency venting to a closed relief system.

These relief systems are normally very conservatively designed. For large, new petroleum refineries with capacities around 300,000 barrels/day (bbl/d), this can result in costs of up to 1% of the total refinery capital investments (Capex)

Overpressurization of process units can occur due to s]. everal reasons as indicated in API-52. Some of those reasons are the following:

- General power failure
- Cooling water failure
- Instrument failure
- External fire

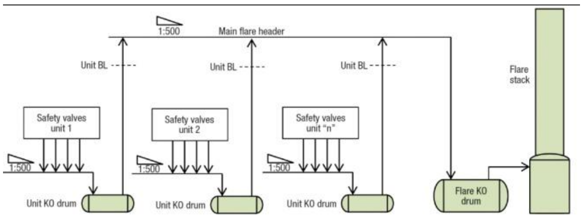
Normally, general power failure or utility failure results in the highest vapor load for a closed pressure-relief system, and is therefore used as the design case. Before sizing a closed relief system, it is advisable to reduce these very high vapor loads by the following:

1. Use high-integrity protection systems (HIPS) as recommended in API-521, which can result in a significant reduction of the vapor flowrates to the flare.
2. Realize dynamic-system load modeling. This analysis for a complete petroleum refinery is very complex and is not normally used, but it can also result in flowrate reductions.

After defining the minimum possible vapor flowrates that correspond to the overpressure relieving rates defined by the design case, the closed relief system may be sized.

Traditional Closed Systems

A closed pressure-relief system is designed to safely control over pressurization of process units during emergencies by relieving the vapors to the flare, which destroys hydrocarbons in a high-temperature flame. Figure 1 shows a typical closed relief system that collects vapors and liquids in process-unit headers and separates the liquid in process-unit knockout (KO) drums before sending the vapor phase to the main flare header, and finally to the flare unit for destruction.

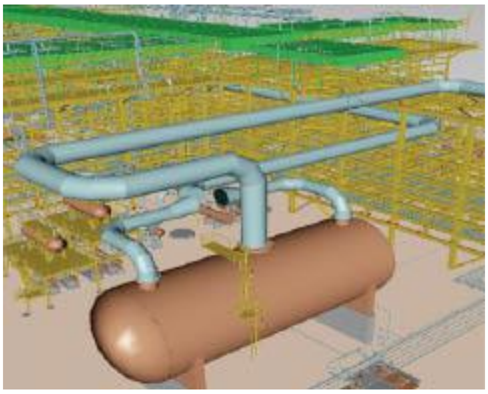


In the traditional system, the unit KO drums and the flare KO drums are projected for the maximum vapor and liquid flowrates as determined from the analysis of the overpressure causes and indicated in API-521.

The KO drums, process units and flare unit, are sized to separate particles in the range of 300–600 μm in diameter, and to hold liquid discharge for 20 to 30 minutes as per API-521 item 7.3.2.1.2 for these maximum flow conditions.

The unit flare headers and the main flare header are also sized for these maximum flowrates. All the headers slope with a minimum inclination of 1:500 toward their respective KO drums, and are continuously purged using combustion gas or nitrogen from the upstream end toward the KO drums to avoid ingress of air into the system.

Optimized Closed Systems



The calculation criteria for sizing the flare KO drums and process-unit KO drums result in very large vessels. This implies the need to install the collection headers very high above grade level, since they must drain to the KO drums. Equipment, such as air coolers that must be mounted above the process unit headers are consequently also very high. This requires long stretches of process piping to and from the equipment. Figure 2 shows such a situation.

If it was possible to change the design criteria for the process-unit KO drums, the process-unit flare header and the air coolers may be installed at a lower level with considerably lower installation costs as a result of the use of less structural steel and process- and flare-header piping.

At the flare unit, the KO drum is even larger than the process unit drums, and as a result, the main flare header at the inlet to the vessel is very high, as can be seen in Figure 3. Consequently, the main flare header at the flare-unit battery limits (BL) is also very high. Since the flare header in large, new, petroleum refineries is normally very long (about 2 km), it means that at the farthest point from the flare unit the header is at least 5 m higher than at the flare-unit battery limits. This installation requires a lot of structural steel to maintain the flare header at the required height, and consequently high investment costs for the pipe rack are required (Figure 4).

The criteria used to size the KO drums for carryover of droplets that are 600 μm in diameter is, according to API-521, to eliminate the possibility of incomplete combustion with excessive smoking, possible "burning rain," and even flame-out of the flare.

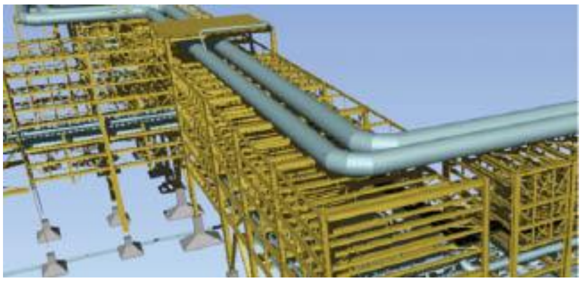
It is clear that the flare unit KO drum must be sized according to this limitation as it is upstream of the flare. However, this limitation is not necessary for the process unit vessels, as these are upstream of the flare-unit KO drum. In this case, if large droplets are carried over from the process-unit KO drums, the flare-unit KO drum will retain them and maintain adequate conditions for the flare.

API-521 item 6.4.3.6.7 presents a clear explanation of the design parameters for these vessels:

"Some flare systems require a flare knockout drum to separate liquid from gas in the flare system and to hold the maximum amount of liquid that can be relieved during an emergency situation.

"In general, a flare can handle small liquid droplets. However, a knockout drum is required to separate droplets larger than 300 μm to 600 μm in diameter in order to avoid burning liquid outside the normal flame envelope. If unit knockout drums are provided upstre “Knockout drums are typically located on the main flare line upstream of the flare stack or any liquid seal. If there are particular pieces of equipment or process units within a plant that release large amounts of liquid to the flare header, it is desirable to have knockout drums inside the battery limits to collect these liquids. This reduces the sizing requirements for the main flare knockout drum, as well as facilitates product recovery.

aim of the main flare knockout facilities, these drums may be sized to separate droplets typically greater than 600 µm in diameter. The use of unit knockout drums effectively reduces the sizing requirement for the main flare knockout drum andfacilities,.



“The liquid hold-up capacity of a flare knockout drum is based on consideration of the amount of liquid that can be released during an emergency situation without exceeding the maximum level for the intended degree of liquid disengagement. This hold-up should also consider any liquid that can have previously accumulated within the drum that was not pumped out. The hold-up times vary between users, but the basic requirement is to provide sufficient volume for a 20 min to 30 min emergency release. Longer hold-up times might be required if it takes longer to stop the flow. It is important to realize as part of the sizing considerations that the maximum vapor release case might not necessarily coincide with the maximum liquid. Therefore, the knockout drum size should be determined through consideration of both the maximum vapor release case as well as the release case with the maximum amount of liquid. ”

Analyzing the above, we can conclude the following:

1. Process unit KO drums are not mandatory.
2. There is no size limit for droplet carryover of process-unit KO drums — larger than 600 µm in diameter is permitted.
3. Process-unit KO drums, if installed, are provided to collect liquid.
4. Flare-unit KO drums must be sized in order to retain droplets larger than 600 µm, as it is upstream of the flare.
5. Process-unit KO drums should be designed to provide sufficient volume for 20–30 min emergency liquid release unless the expected response time is longer.

Taking into consideration the above conclusions, the process-unit KO drums can be sized considering basically only the liquid hold-up time. The flare-unit KO drums, located downstream, will collect liquid droplets larger than 600 µm in diameter. Therefore, the criteria for sizing process-unit KO drums can be changed from separation of droplets greater than 600 µm in diameter to liquid hold-up.

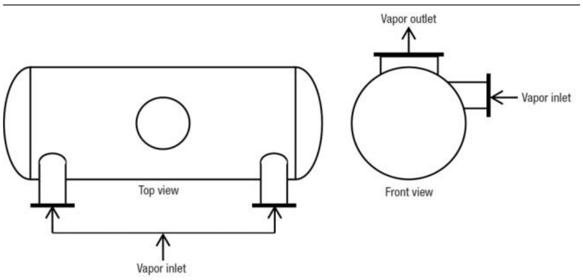
As there is no worry about droplet carryover, it is possible to consider the use of vertical KO drums in the process units instead of a horizontal vessel, as they present several advantages when designed only for the collection of liquid as seen below:

- Smaller vessel
- Has a smaller footprint and can be installed closer to the pipe rack
- The height of the process unit header is lower, which saves on structural steel in the pipe rack
- The arrangement of the process unit header can be simplified, resulting in a smaller total length
- Air coolers, if installed, can be lowered, reducing process piping to and from the equipment
- Reduced weight of the pipe rack and KO drum reduces foundation requirements
- These vertical KO drums can be designed without internals, and with the outlet flare nozzle at 180 deg from the inlet nozzle and at the same elevation, as the liquid droplet carryover is not in question. However, the designer should avoid very large droplet carryover, which results in vessels with a smaller length-to-diameter ratio than usual for vertical gas-liquid separation vessels. The reason to remove very large droplets in the process units is not to overload, with liquid, the new main header proposal presented below.

- As can been seen in API-521 item 6.4.3.6.7 (quoted earlier), process-unit KO drums are not mandatory. But, because condensation always occurs in flare headers, it is recommended to maintain the process-unit KO drum unless this header can be drained to the main flare header outside the battery limit (OSBL).

- This change of design criteria for the process-unit KO drums will reduce the vessel volume by up to 80%, resulting in a considerable investment-cost reduction for the inside the battery limit (ISBL) relief system.

- OSBL cost reductions may be obtained for the main flare header by reducing the elevation above grade level of this very large (diameters around 80 in.) and long pipe. This can be done in two steps — the first of which is to reduce the header height at the flare unit battery limits. This may be done by a simple alteration of the header’s inlet piping arrangement to the very large, horizontal flare-unit KO drum — which can be over 8-m dia. — by changing the vertical inlet connections to horizontal ones, as indicated in Figure 5. In large petroleum refineries, this alteration to the inlet connections can result in a reduction of the header height at the flare unit battery limits by more than 4 m.



The second step is to reduce the large increase in height of the main flare header from the flare unit to the farthest process unit because of the required slope of 1:500. This may be achieved by installing a vessel and pumps along the pathway to collect condensate, thus dividing the header into two approximately equal parts. The first part is from the farthest process-unit drains to the header collection vessel, and the second is from this vessel to the flare-unit KO drum (an intermediate main-header KO drum).

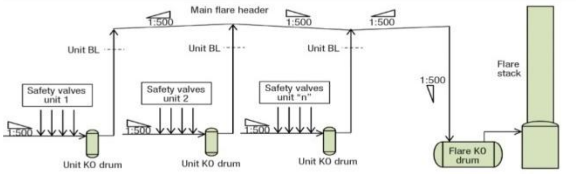
This suggestion is based on API-521 item 7.3.1.3.8, which states: “A small drain pot or drip leg can be necessary at low points in lines that cannot be sloped continuously to the knockout or blowdown drum.

An alternative to the installation of a second main-header KO drum and pumps, which require additional investment costs, is to integrate the process units with the main flare header by carefully designing the process-unit KO drums and headers.

This alternative is to use some, two or three, of the process-unit KO drums to receive condensate from the OSBL main-flare header. In this case, it is important to make sure that the liquid hold-up capability of the selected process-unit KO drums considers this additional service requirement and that they are adequately sized. It is also necessary to make sure that the response time used to size all the process-unit KO drums is adequate and that large quantities of liquid will not be carried over to the main flare header. Provisions must be made to permit isolation of the process-unit KO drums used for this service from the process units during shutdown.

This installation collects condensate formed in the main flare header along its extension, reducing the amount carried over to the flare-unit KO drum and permitting a reduction in its size.

Figure 6 shows a schematic design of a closed pressure-relief system using the alternatives suggested in this section.



Further integration of the ISBL and OSBL flare projects can bring gains by considering the pressure profile of the main flare header determined by the refinery-flare design case. The pressure at the battery limit of the process unit farthest from the flare unit will be higher than the process unit closest to the flare unit. In the traditional approach, the maximum pressure at the battery limits of all the process units is defined as a constant value and is the same for all process units.

Taking this into consideration, this profile permits that the process units nearest to the flare unit can reduce the diameter of the ISBL flare headers until the maximum permitted back pressure is reached for the most critical pressure-safety valve (PSV). Normally the most critical PSV is the valve with the lowest set pressure. All ISBL headers should be designed for the maximum possible velocity and values of over 35% of the Mach number should be pursued, but limited to 50%, and approximately maintained along the ISBL header, by adjusting the diameter to minimize header costs.

The main flare header should also be sized carefully, to minimize the diameter, by considering the maximum possible process-units battery-limit pressures defined by the back pressure of the PSVs. Once more, the diameter of the header should be adjusted to maintain the vapor velocity for the design case, which is approximately constant from the farthest process unit to the flare unit.

Cost Savings

As can be seen from the above discussion focused on petroleum refineries, fairly simple project considerations can reduce the cost of construction of a closed pressure-relief system. It is possible to significantly reduce the size of the process-unit KO drums, while at the same time save considerable structural steel used for the ISBL and OSBL pipe racks. It is also indicated that by careful calculations of the closed flare system with integration of the ISBL with OSBL, it is possible to reduce the flare header diameters. In comparison with the traditional approach, this new manner to project the pressure relief system offers a reduction of about 30% in the height of the main flare header and around 20% in the height of the unit flare headers. This together with the much smaller unit KO drums, reduced header diameters and less process piping for the lowered air coolers, permits an investment cost reduction for the relief system of up to 20% as compared with the traditional project.

Vishal Sharma (Third Year)

Focus on Industrial Hygiene

This Hood Captures Unwanted Fumes from Work Spaces

The Purair Advanced P20 Ductless Fume Hood (photo) is designed to protect workplace operators from hazardous substances. It provides a face velocity of 100 ft/min to contain fumes. The unit is 49-in. wide, by 27.5-in. deep, by 47.5-in. high. Other sizes are available up to 96 in. wide. The primary filter can be chosen from 14 different types of carbon, including specialty media that is designed to remove vapors of organic compounds, solvents, acids, mercury and formaldehyde. HEPA filters for the removal of particulate solids are also available, to suit specific application needs. The Purair can also be equipped with a secondary backup filter to meet ANSI Z9.5 section 4.12 4.2 requirements. An alarm alerts operators when the airflow falls to an unacceptable level. Switches and electrical components are isolated from the contaminated airflow. The work area has a removable, cleanable spillage tray. Optional integral lighting is available.

Mezzanine Gate reduces the Risk of Worker Falls and Injuries

The Protect-O-Gate Pivot Gate (photo) can be customized to accommodate various configurations. The pivot gate eliminates the potential for falls and other accidents often associated with mezzanine loading areas. The unit is counter-balanced and operator-friendly, says the company, to provide easy access to staging areas. Unlike conventional devices, such as chains, lift-out gates and sliding gates, this pivot gate cannot be bypassed. When the enclosure closest to the edge of the mezzanine is lifted to allow load delivery, the second enclosure rests on the mezzanine, protecting personnel from potential falls. Custom sizing is available, with optional increased loading height available to 80 in. Any dimensions can be modified to meet your specifications. The unit is shipped assembled, so it can be bolted to the mezzanine floor and put into operation immediately.

These Absorbent Products Help Ensure Workplace Safety

The eco-friendly Oil Eater Naturals line of absorbent pads, rolls and socks (photo) is available to help facility personnel respond to spills and leaks in the workplace — anywhere drips or spills can cause slippery conditions. The product line is made from natural plant byproducts and has woven construction. Oil-Only pads and rolls soak up oil and repel water. Universal Pads and Rolls soak up oil, water and other liquids. Absorbent socks are available to contain larger spills and protect drains. All come in various weights, finishes and sizes.

Electrical Enclosures Can Be Modified To Add Height

This company's standard 72-in.-tall cabinets and enclosures (photo) can be customized to a height of 90-in., to meet user requirements, when floor space is limited but vertical space is available. The company has modified its two-door, floor-standing 1422 and HN4FM series, and the single-door free-standing 1418 and HN4FS series (to 90-in. height), all of which are available in either painted mild steel, or 304 or 316L stainless steel construction. When used to house control or electrical equipment, the larger surface area of the taller metal cabinets also improves conduction, which can help to reduce cooling needs and thus reduce energy use.

This Small-Scale Workstation Captures Fumes

The MicroFlow II is a small-scale, Class 1 ductless carbon-filtered workstation (photo). It is designed for general chemistry applications involving the handling of small volumes of chemicals, such as solvent cleaning of electronic parts, tissue staining and processing, gluing and drying operations, soldering applications, and more. It is equipped with activated carbon filtration, to capture fumes, odors and non-hazardous chemical vapors. It is completely self-contained with an integral, recessed work surface to contain spills. Variable-speed fan control allows for high-speed 100-ft/min air flow through the sash. A light indicates when it is time to replace the filter.

Surveillance Camera Provides extended Wi-Fi Range

The Apollo Pro Camera allows facility managers to maintain surveillance, to monitor day-to-day operations for workplace safety, quality control, theft prevention and remote monitoring. Its long-range capabilities provide three times the Wi-Fi range of other competing cameras, says the company, and this allows operators to carry out security surveillance coverage in places never before possible. The Apollo Pro is equipped with a wide viewing angle, and advanced night vision capabilities provide clear viewing in dark conditions. A free app allows users to set up, view, listen, talk to, control and edit all of their Apollo Cameras from any device.

XenonStrobe Beacons Have Multiple Configuration Options

To complement its GNEx family of alarm horn sounders, loud speakers and manual call points for activation of fire alarms, gas detection and emergency-shutdown systems, this maker of audible and visual warning signals now offers the BNEx GRP Xenon strobe beacons (photo). Suitable for all Zone 1, 2, 21 and 22 hazardous location applications, the explosion-proof and corrosion-resistant GNEx beacons have extended temperature range with IECExad ATEX Ex d approvals. For signaling in applications with high ambient light, or for long-distance signaling, the GNExB2 beacon is available in 10, 15 and 21-Joule variants, producing a very high output Xenon strobe. Both 15- and 21-Joule versions can be supplied with a plate-mounted assembly configured with up to four xenon strobe beacons with a junction box, or five beacons without a junction box

Response Kits Help Personnel Deal with Industrial Spills

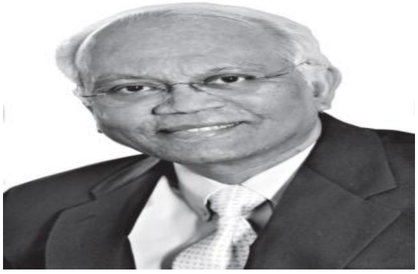
The TaskBrand Spill Kits (photo) are available to help plant personnel respond immediately to liquid spills, leaks or discharge of hazardous chemicals. The kits can be configured to contain different types of spill-response products, so they are ready for potential scenarios that could occur in different areas of the plant. For example, kits are available for universal spill types, for oil-only spill types, and for chemical applications. The TaskBrand kits come in 5-, 20-, 30-, and 65-gal capacities, and include gloves, safety goggles, a reusable bucket or laboratory pack/overpack, and the appropriate number of socks, pads and can liners to allow plant personnel to respond to spills. A vehicle spill kit is also available, consisting of two pads, two sorbent socks, and two clean-up bags

Low-Profile Led Light Fixture Is Rated For 100,000 H of Service

The HAL-LED-CPR-40 is a 40-W, low-profile, LED light fixture that is approved for Class 1, Division 2 hazardous locations, while also carrying an ATEX Zone 1 and 2, as well as PSE and SAA certifications. It is said to provide a powerful and energy-efficient alternative to metal halide luminaries. This hazardous-area light fixture provides 4,000 lumens of light, while drawing only 40 W of power. It is constructed of durable, die-cast aluminum and comes with a tempered-glass lens that provides protection for the 24 individual LEDs that deliver high-quality light in a 120-deg beam spread.

Alisha Mansuri (Second Year)

Dr. R.A. Mashelkar



Chairman, National Innovation Foundation India

Dr. R.A. Mashelkar is presently a National Research Professor and also the President of Global Research Alliance, a network of publicly funded R&D institutes from Asia-Pacific, Europe and USA with over 60,000 scientists.

Dr. Mashelkar served as the Director General of Council of Scientific and Industrial Research (CSIR), with thirty-eight laboratories and about 20,000 employees for over eleven years. He was also the President of Indian National Science Academy.

Deeply connected with the innovation movement in India, besides being a Member of Prime Minister’s National Innovation Council, Dr. Mashelkar is also the Chairman of India’s National Innovation Foundation, Reliance Innovation Council, Thermax Innovation Council, Marico Innovation Foundation and KPIT Technologies Innovation Council.
Dr. Mashelkar is a Fellow of Royal Society (FRS), London, Foreign Associate of National Academy of Science (USA), Foreign Member, American Academy of Arts & Sciences (2011); Foreign Fellow of US National Academy of Engineering (2003); Fellow of Royal Academy of Engineering, U.K. (1996), Foreign Fellow of Australian Technological Science and Engineering Academy (2008) and Fellow of World Academy of Arts & Science, USA (2000).

Dr. Mashelkar is on the Board of Directors of several reputed companies such as Reliance Industries Ltd., Tata Motors Ltd., Hindustan Unilever Ltd., GeneMedix Life Sciences Ltd., Piramal Enterprises Ltd., and KPIT Technologies Ltd.

In the post-liberalized India, Dr. Mashelkar has played a critical role in shaping India's S&T policies. He was a member of the Scientific Advisory Council to the Prime Minister and also of the Scientific Advisory Committee to the Cabinet set up by successive governments. He has chaired twelve high powered committees set up to look into diverse issues of higher education, national auto fuel policy, overhauling the Indian drug regulatory system, dealing with the menace of spurious drugs, reforming Indian agriculture research system, etc.

In August 1997, Business India named Dr. Mashelkar as being among the 50 path-breakers in the post- Independent India. In 1998, Dr. Mashelkar won the JRD Tata Corporate Leadership Award, the first scientist to win it. In June, 1999, Business India did a cover story on Dr. Mashelkar as "CEO OF CSIR Inc.", a dream that he himself had articulated, when he took over as DG, CSIR in July 1995. On 16 November 2005, he received the Business Week (USA) award of ‘Stars of Asia’ at the hands of George Bush (Sr.), the former President of USA. He was the first Asian Scientist to receive it.
Thirty universities have honoured him with honorary doctorates, which include Universities of London, Salford, Pretoria, Wisconsin and Delhi.

The President of India honoured Dr. Mashelkar with Padmashri (1991) and with Padmabhushan (2000) in recognition of his contributions to nation building.

Amir Ansari (Second Year)

Geothermal energy

Steam rising from the Nesjavellir Geothermal Power Station in Iceland.

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials (in currently uncertain[1] but possibly roughly equal[2] proportions). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective geothermal originates from the Greek roots γη (ge), meaning earth, and θερμος (thermos), meaning hot.

Earth's internal heat is thermal energy generated from radioactive decay and continual heat loss from Earth's formation.[3] Temperatures at the core–mantle boundary may reach over 4000 °C (7,200 °F).[4] The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically, resulting in portions of mantle convecting upward since it is lighter than the surrounding rock. Rock and water is heated in the crust, sometimes up to 370 °C (700 °F).[5]

From hot springs, geothermal energy has been used for bathing since Paleolithic times and for space heating since ancient Roman times, but it is now better known for electricity generation. Worldwide, 11,700 megawatts (MW) of geothermal power is online in 2013.[6] An additional 28 gigawatts of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications in 2010.[7]

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly,[8] but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels. The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, and interest rates. Pilot programs like EWEB's customer opt in Green Power Program.

Utkrash Thote (Third Year)