How to mothball and decommission industrial plants: before you put the key in the lock, make sure you know what to do.

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Industrial facilities have a finite operating lifetime. The most common reasons for shutting a plant down include loss of market for the product, its falling price, or high rehabilitation costs to keep the plant going. When you are dealing with a major facility, you can't just lock the door and walk away. There are a large number of actions required. Here is an introduction to what you need to know.

Make It Safe

First make the plant safe. Any existing product must be drained from the main circuits as well as any hazardous materials that might be in any secondary circuits. Flush these circuits with water and collect the flushings for treatment before disposal. Low points in piping and buried pipe that cannot be drained may be flushed with water or a solvent to displace/remove remaining product.

Internal equipment atmospheres may need to be tested for explosion or toxic hazard, and, depending on the test result, purged to a flare or vapour recovery system. Once a safe internal atmosphere has been established, the equipment can be opened for inspection. Start with inspections that can be done without entry as vessel entries can be complicated by safety considerations, e.g., whether fugitive sludges or deposits in the vessel contain hazardous material that should be removed by lancing, by mechanical, or by chemical methods. If the equipment is to be saved, it may be prudent to remove deposits and scale.

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material that should be removed by lancing, by mechanical, or by chemical methods. If the equipment is to be saved, it may be prudent to remove deposits and scale.

Mothballing

If there is any likelihood that the plant might be restarted over the next few years, you might want to set up protected storage conditions or mothballing until that final decision is made. If you do decide to run again within 3 to 10 years, you should be able to get it back up. If you haven't decided to use it within that time, the chances are that it will never be used again and it's time to proceed with the dismantling and site-clearing option.

Most industrial plants are constructed from carbon steel which, if given half a chance, will revert back to the ore from which it started, i.e., it will rust. A lot of thought must go into establishing conditions to minimize the deterioration from rusting. A checklist should be established covering all items in the facility, specifications written for each category, and finally estimates made to review the cost-effectiveness of mothballing each category. It might make sense to let some equipment deteriorate in place and then replace it with updated equipment before any future re-start, e.g., reverse osmosis membranes could suffer severe microbiologically-induced damage. A difficult situation could arise when plants have parallel units or trains. Suppose the B unit is kept running, as it can supply the current product demand, and the A and C units are mothballed. It doesn't take much imagination to guess that the simplest way to maintain B will be to pirate components from the mothballed units, thus making it impossible to get those units back on-line.

Protecting Equipment Internals

The protective oxide formed during operation should provide some initial protection. It's unlikely that significant rusting will occur in the first week or so, other than at air-liquid interfaces. As the shutdown continues into weeks, that protection will start to fail. To maintain a protective state, the system should be stored either totally wet or totally dry, whichever is more appropriate for the individual situation ... and then even after setting up all the conditions, they can be upset by a future entry into the system for some form of maintenance or inspection. You can only do your best and expect a burst of oxides to peel off the surface as the unit goes back on line.

Wet storage may be preferable for some systems. Fill the system to the top and try to provide some circulation, even if it's slow. A turnover time of a few days is acceptable. Use the best water you can get, preferably demineralized and add ammonia or morpholine to raise the pH to 9.5 and 100 mg/L of hydrazine or an organic oxygen scavenger to remove the dissolved oxygen.

Dry storage requires draining the system and blowing dry air or nitrogen through it to dry any residual moisture, particularly the puddles at low points as rust will form quickly at the air-water interface. There are two methods to obtain drying air without heating. Use plant compressed air if it's available and dried (as most systems are to a dew point of -40), or use atmospheric air when its humidity is low. The progress of drying can be measured with a hygrometer as the air emerges from the equipment. When inlet and outlet air have the same dew point, the equipment can be closed and left overnight to soak up any residual moisture before repeating the purging process until all signs of moisture are gone. New, low-cost rubber gaskets should be used for the mothballing period only. After inspection, cleaning and drying are complete and the system is closed up, do a leak test at 15 psi. Any large leaks will be found by listening, and small leaks by soap bubble testing. Alternatively, a volatile tracer

may be put into the system's internals for detection by chemical means at possible leak points.

Many older mothballing procedures set out desiccants in open trays to pick up residual moisture. Some applications succeeded; others failed when the desiccants became saturated over time. Their usage must be monitored to check when they need to be replaced. Unfortunately, that also requires opening the system and letting in more moisture. It's probably impossible to thoroughly dry a system and this has lead to the development of a large family of volatile corrosion inhibitors or VCIs, that can form protective coatings on the surface. These are based upon proprietary amine formulations and usually are added in bags or canisters. They can also be impregnated into papers to wrap smaller components.

Large industrial plants have many pieces of mechanical equipment that must be protected, each in their own way. Where grease is normally used, fresh grease is applied. Shafts are coated in grease. Fluids are replaced with materials recommended by the equipment manufacturers for use during long-term storage. Unless machinery is to be rotated periodically, bearings should be removed, and the shafts supported on blocks. If indoor storage is available, impellers and rotors may placed inside after being clearly tagged. The same applies to motors above a certain horsepower. Small, standard motors may not be worth the effort. For removed motors, install protective caps on the cable ends in the field. Include some form of vermin control to prevent them from chewing the electrical insulation.

Additional measures are required to protect exposed equipment. Glean anchor bolts and coat them with a molybdenum-based oil paste. Denso Tape might be more effective for studs than a grease. Carbon steel equipment should be touched up with recommended paints, or if an extensive touch-up is indicated, sandblast and prime the entire piece. Joints in equipment bodies are an ideal site for corrosion and the incentive that lead to the development of WD-40 and other formulations. For painted equipment, apply these formulations after painting. The U.S. military developed cocooning films for equipment, which may outlast painting for long-term storage facing the elements. However, such films may prove to be expensive or not readily available, and the films may not hold up well at flanges. Painting or cocooning is not necessary for stainless steel and fibreglass. Pipe hangers need coating and greasing. Hydraulic and spring hangers should be locked into their shutdown position, with careful recording of this for the future re-start.

With their many crevices, variety of materials, and actuator housings, it's tricky to protect valves in the field. If warehousing is available, it may be justified to remove the more expensive valves and actuators and installing blinds on the mating pipe flanges left in the field. An alternative is to cover the entire valve with a strippable film such as Ashland's Tectyl 506 or coal tar epoxy. Such coatings should receive annual touch-ups at sharp corners. Instrumentation, cabinets, small electrical parts generally should go to indoor storage. They require tagging that relates them to their position in the process, and to their manuals. Because instrumentation becomes obsolete quickly, it may be appropriate to consider scrapping it and replacing with new when the plant comes back on line.

Insulation is susceptible to weather-damage. Cladding can loosen as bands and supports deteriorate. To reduce the hazard of falling material, it should be inspected when mothballed and again annually with any indication of failure repaired promptly. Wet insulation will present a corrosion hazard to the underlying steel and tubing. Inspection should check the underside of horizontal lines and vessels for water by making a tiny hole to observe if water runs out. Tower domes and dished heads are especially susceptible to the ingress of rain

because of installation difficulties with the segmental shapes. Caulking may require periodic replacement. The replacement of tower dome insulation is costly because of scaffolding

requirements. Failed insulation should be removed if the lay-up is to continue with the exposed steel sanded at rusted places, and painted with micaceous iron oxide or an equivalent primer. Then the exposed ends of remaining insulation are sealed with metal and/or caulking.

Caretaking

The preparations for caretaking are the same as shutdown procedures for maintenance with some additional steps added because of the anticipated long out-of-service state. These may include:

* periodic fluid changes and rotations for mechanical and electrical equipment

* periodic checking for wet insulation and loose coverings

* lighting maintenance, sewer operation checks, enclosure integrity checks

In addition to the mothballing specifications for the equipment, record-keeping needs to be specified, with provision for secure duplicate records. Those work and inspection records may be valuable when the start-up is being evaluated.

Can the Plant be Mothballed Forever?

The successful long-term lay-up of a chemical facility is a significant undertaking. Mothballing requires technology that may be partially derived from technical considerations by those familiar with the facility, and partially from review of the literature on the subject. It can only be a temporary situation and eventually a decision must be made. If the plant will never be run again, it should be dismantled and the site cleared. Estimates should be obtained for demolition and to find what can be recovered. An economically important part of the information given to the prospective contractor is a 'bill of materials' estimate of the scrap quantities. For example, how many tons of each recyclable metal and how many miles of heavy electrical cable will result, etc. Generally, the owner will do well to recover five cents on the dollar for selling equipment, with a much better recovery from the sale of large transformers, large motors, switchgear sets and high alloy tanks small enough to be moved. Be aware that a n environmental audit must be made and that it will be a major part of dismantling process.

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