$25,000-$75,000/day.[3] A three-week shutdown, therefore, can mean a million dollars in lost revenue. Historically, the trend has been toward reducing engineering costs. Perhaps the time has come to reverse this tendency. A 20% increase in engineering manhours may only cost the equivalent of 150 hr or less of plant operating time—not a steep price to pay for more dependable systems.

Inadequate support facilities—poorly specified, improperly operated—lead to startup headaches. Shortages of boiler feedwater, incorrect water treatment, poor (and often erroneous) interpretation of startup procedures—these all introduce startup problems.

Moreover, process equipment usually receives priority during startup, with support facilities receiving only secondary attention. *Considerable work must be undertaken in setting standards and establishing design specifications for many types of basic support facilities.*

Steam generators are a case in point. Designed for essentially continuous operation, they are not suited to the severity of swings which occur, for example, in a refinery or chemical plant complex. Steam-generator designers talk in terms of 10% load change in 3 min as being compatible with their equipment. Reluctantly, *they will offer a 20% maximum load* change in 3 min, with either packaged or field-erected boilers. Additional surge capacity in the steam drum does not solve the problem. Nor does imposing special standards or requirements, because the supplier probably will refuse to quote or will quote too *high with exacting specifications.*

Increased integration—how good?

Plants are becoming more highly integrated and contain more sophisticated instrumentation than ever before. For example, compressors now are called upon to handle various loads on the same frame. While economics may justify such decisions initially, augmented startup problems can wipe out any potential savings.

A mathematical equation has been proposed that expresses the number of possible upsets (Z) which may occur in a system as a function of the degree of integration[2]:

$$Z = \frac{k}{2}(1 + k),$$

where k is the number of integrated influences. It appears to be born out by experience. Applying it, we find that the number of failures increases rapidly as integration edges upward. *From one failure for* one integrated influence, the number becomes 21 for six influences.

While not a precise relationship, the curve representing this equation (preceding page) indicates what may be expected in the way of additional costs as the degree of plant integration increases.[2] Only startup costs are shown; savings in initial plant cost due to integration are not reflected.

A criterion of this type should be applied during initial planning of all large projects to help predict the amount of money required for plant startup. In a number of instances, protracted startups have created severe financial crises for the plant owners involved. Applying the equation reveals a need for greater and greater emphasis on engineering as plant sizes go up. ●

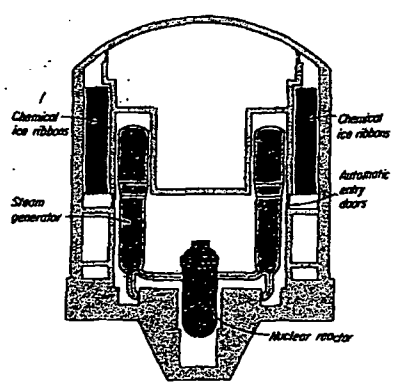
References:
1. Economics of Plant Startups, R P Feldman, Chemical Engineering, Nov. 3, 1970, p 87
2. Fire and Explosion Risks in the Modern Ammonia Plant, H Rathmann, Safety in Air and Ammonia Plants, Vol 10, '68, AIChE
3. Influences of Startup Delays on Large-Scale Ammonia Plants, E Bogner and T Glasweacker, Nitrogen, No 67, Sept./Oct., '70, p 27

Ice ribbons safeguard nuclear reactor

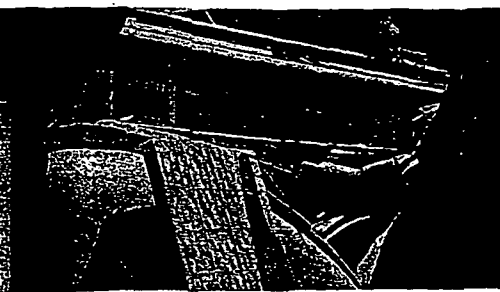
A new ice-storage system reduces the cost of containment structures for nuclear reactors by more than 20% and also improves safety. This patented system uses subcooled chemical ice ribbons developed by Flakice Corp to condense any steam leaks in 10 seconds or less. Compare this with the two hours or more required by waterspray injection and other emergency cooling systems.

Conventional method of safeguarding a nuclear reactor requires its placement within a building of sufficient size to insure against pressure rises above 60 psig, even in the unlikely event of gross rupture of the reactor coolant system. This method, a Westinghouse advancement, rings the wall of the containment vessel with roughly 1500 tons of ice within an insulated cold-storage compartment. When triggered by a slight rise in pressure, doors operate automatically to open the passage between ice and reactor (drawing). The massive low-temperature heat sink thus formed reduces maximum possible transient pressure to less than 15 psig. Also, system reduces reactor containment space by 50%.

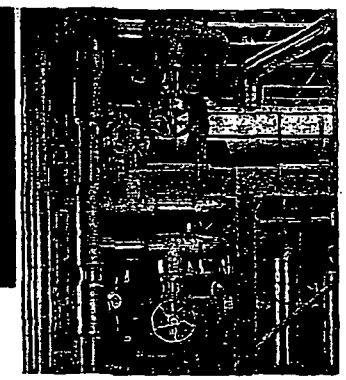
Ice ribbons are harvested continuously by peeling from a flexible freezing surface, producing ice of the same chemical concentration as solution from which ice was frozen. AEC has approved the system, which soon will see service in two U.S. nuclear power plants.



Containment system uses chemical ice solution and recycles solution to maintain subcooled temperatures



Duct insulation, factory-scored to reduce dust production during cutting at site, gets trimmed in preparation for installation on tank head



Metal jackets replace older asbestos-containing finishes and jackets, reduce dust from subsurface

Air, gas and liquid handling

Breathe easier with today's insulation

By Walter K Hesse, Johns-Manville Corp

Increasing concern is expressed in industry, labor, medical and government circles about the high rate of asbestos-related diseases—asbestosis, lung cancer and (rarely) mesothelioma—in buildings, industrial plants, ships. Workers who have been employed for over 20 years give special concern.

But situation is getting better. Consider first that the abnormally high death rate of recent years among older employees reflects exposure to asbestos dust accumulated over the past 40 years. This death rate should diminish because the amount of asbestos dust to which insulation workers are exposed has decreased considerably over *the past two decades. The younger* workers (fewer than 20 yrs on the job) have had significantly less exposure in comparable work periods.

In the 1930's, practically all insulations contained some asbestos fiber. Its content ranged from 10% for diatomaceous silica to 100% for "mine" cements. Latter, mixed with water, were used to point up joints in molded or formed block insulation and over fittings and block insulation. Today, one-coat hydraulic setting *mineral fiber cement, with only 15%* asbestos-fiber content, is common.

A popular high-temperature insulation had been 85% magnesia, with about 14% asbestos by weight. But a new product, calcium silicate, joined the high-temperature group in the early 1940s, eventually replacing 85% magnesia and diatomaceous silica *for the* 300-1200-F range. Calcium silicate contained only 11% asbestos fiber initially, and this later fell to 7.5%. The group of high-temperature insulations accounted for about 64% of the total U.S. volume.

So-called low-pressure insulations were used for temperatures between *50 and 250 F* and contained about 75% asbestos by weight. These materials included air-cell sheets and pipe insulation consisting of alternating corrugated and plain asbestos paper bonded with sodium silicate, in addition to wool-felt sheets and pipe insulation consisting of rag and wool fiber paper, laminated and bonded.

Growth of the petroleum and chemical industries built up demand for low-temperature insulating materials such as foamed glass in the 1940s *and 1950s. By the end of the 1940s,* fiber-glass insulations accounted for nearly 25% of all insulation materials produced. Today, fiber-glass products hold a 50% share of the insulation market. Although asbestos fiber production increased over 400% from 1930 to 1965, the amount used in insulation materials decreased slightly during the same period. ●

Fiber-glass pipe insulation receives final touches on boiler-room piping and valve installation at state university plant

Solid vs sprayed-on

Current attacks on use of asbestos for various purposes because of its *health effects should* be understood as not directed primarily at pipe and equipment insulation. Efforts like those outlined in the article have made this end-use comparatively safe. Instead, spraying of asbestos fireproofing on the steelwork of new buildings has become a major target. Legislation to require substitutes for asbestos in this work is under study and, as in the case of New York City, has been proposed for safety of workers and passersby.