

should be tested for flammable and toxic gases, and for inadequate oxygen. These tests must be repeated at intervals to make sure that conditions remain safe while men are in the vessel. Air should be introduced to make sure there are several air changes per minute in the vessel.

After all preparations for entry are made, the supervisor of the area should check that the vessel is safe, that all lines are closed off, that power sources are locked out, that ventilation and personal protective equipment are adequate, and that safe work procedures are planned. He can then issue a "vessel entry permit," a note that certifies all precautions have been carried out.

Men should not be lowered into vessels without facilities for them to climb back out themselves (if it can be avoided). Straight ladders or rope or chain ladders with rigid wood rungs should be provided. Also, men should not be required to go into an opening that they must squeeze through. They cannot be removed quickly in an emergency.

Another necessary precaution is to have men don safety harnesses attached to lifelines before entering any vessel. An observer equipped with similar respiratory protection and harness with a lifeline should be stationed outside the vessel. This man should also have some device for signaling for more help, one man's efforts might prove inadequate.

Depending on the previous content of the vessel, the man entering the vessel should be equipped with a vapor-proof flashlight or vapor-proof low-voltage extension light. At times, a chemical protective suit is advisable.

The method of cleaning depends on the use of the vessel. If it has contained petroleum or chemical products, the vessel may be filled with water, a caustic solution, or a neutralizing agent to remove sludge and adhered materials. Vessels used for flammable liquids should be washed, steamed and/or ventilated until a test with an approved explosion meter shows the level is safe. (See Chapter 42, "Flammable and Combustible Liquids.")

Hydrostatic tests

If a pressure vessel is so constructed that an internal inspection cannot be made period-

ically (length of the intervals depending on the corrosivity of the contents), it should be subjected to a hydrostatic test if the weight of water will not in turn set up damaging stresses. In this latter case, a pneumatic test can be applied. See ASME Code, Section VIII.

Compressed gas or air should never be used to test an unfired pressure vessel above its safe working pressure, although it can be used to test for leaks at pressures below the working pressure. Great care must be used because a vessel may fail under test and shatter. Testing should follow procedures in the ASME Codes and be under the supervision of qualified personnel.

The required pressure for a standard hydrostatic test is normally $1\frac{1}{2}$ times the maximum allowable working pressure of the vessel being tested. Division 2 provides for the establishment of upper limits by the design engineer, in terms of stress-intensity limits relative to the yield strength at test temperature. Inspection of Division 2 vessels is made at a pressure equal to the greater of the design pressure, or $\frac{2}{3}$ of the test pressure.

Test areas should be isolated as far as possible from other operations and suitable barricades should be provided for protection of personnel and valuable equipment. This is especially important when conducting proof tests and tests to destruction.

All personnel should keep clear of the vessel under full test pressure and no one should be allowed to approach the vessel until the pressure has been reduced to, or is very close to, the maximum allowable working pressure.

Detecting cracks and measuring thickness

Pressure vessels used to process gases or oily materials may have very small leaks which will not show under hydrostatic tests. To detect them, a small amount of ammonia can be released inside the vessel and compressed air is then applied until a maximum pressure of 50 percent of the working pressure is attained. A swab soaked in hydrochloric (muriatic) acid is passed over all seams and other suspect areas. Leakage will be indicated by a white vapor (ammonium chloride) formed by contact of escaping ammonia and the acid. Using a burning sulfur stick is also effective—a change in the flame indicat-