below the working pressure Great care must be used because a vessel may fail under test and shatter

### 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 per cent 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 indicates ammonia

Radiography is especially good for finding cracks For example, ammonia tanks used for agriculture are subject to corrosion and may stress crack If care is not taken to catch tanks which become defective, there may be some surprised—and seriously hurt—farmers

Also, there are a number of applications where it is vital to check the thickness of an unfired pressure vessel without damaging it There are a number of manufacturers who make instruments for doing this Some are listed under "Gauges or Gages Thickness" in *Thomas Register*, and include Sperry Products Division of Automation Industries, Inc, Danbury, Conn, and Magnaflux Corporation, subsidiary of General Mills, Chicago Other instruments employ ultrasonic and various electronic-ray producing and measuring means

Using these instruments, a qualified operator can determine the thickness of metal to within 2 or 3 per cent Some, like the Magnaflux test, will disclose cracks which extend or are slightly below the surface The use of a radiograph will then be necessary to determine how deep the cracks are

One large boiler insurance company has developed a lacquer method of detecting hairline cracks that cannot be seen by the naked eye When the head of a pressure vessel is suspected, it is cleaned and given a coat of clear lacquer After the lacquer hardens a hydro test is applied The weak spots, hairline cracks, or fatigue stress cracks will show up as the head expands and cracks the lacquer The more modern dye penetrant tests, when made by competent inspectors according to manufacturers' instructions, are considered quite reliable

At each inspection of such pressure vessels as vulcanizers, digesters, and autoclaves which have removable cover plates, heads or doors, the holding bolts, cover plate bolts, slots and retaining rings should be checked for wear, and hammer tested for soundness Since these parts are badly abused in service and receive considerable wear it is advisable to replace them annually They are comparatively inexpensive

The width of the slot should be gauged and a careful check should be made of the retaining rings and cover plates, as cracks are set up by the stress of improper adjustment or closing of the door plate

If cracks cannot be satisfactorily repaired, the vessel should be condemned

### Operator training and supervision

It is important that employees working with pressure vessels, particularly with those which are used in chemical processes, be thoroughly trained both in routine duty and emergency procedure Supervision, too, should be competent and alert A new employee being trained as an operator or helper should have the entire process explained to him, the hazards involved, and just how his operation affects the entire process

In some plants a check list is used to make certain that no step has been overlooked in the processing cycle The operator or his helper records on a card the information obtained from recording apparatus and thermometers, and the time and frequency at which he operates the valves to each pressure vessel After each complete processing cycle, the operator initials the card check list (shown in Fig 16-6)

If the contents of a pressure vessel are being discharged to a vessel which the operator cannot see, or one run by another operator, a system of whistle, bell, or light signals should be installed The time that these signals are given and action is taken should be noted on the check list so that the wrong valve will not be opened or closed

The plant operating supervisor should instruct operators of vessels with cover plates or removable doors how to tighten the bolts