Reactor-Boiler and Auxiliaries - Course 433

FUEL HANDLING AND STORAGE

There are three general divisions of fuel handling and storage which must be considered. These are:

1. New fuel handling and storage
2. Reactor fuelling
3. Spent fuel handling and storage

A separate lesson on reactor fuelling will be given later which will cover this section in more details than given here.

The details of the handling problems in the three general areas mentioned above are quite different, since the fuel becomes highly radioactive while in the reactor. In all three areas, however, it should be kept in mind that the fuel is expensive and rather delicate. It was noted in the earlier lesson on fuel, that it is desirable to keep structural materials in the fuel to a minimum, so that a minimum number of neutrons are captured. This results in fuel assemblies which have a very small factor of safety in structural strength to allow for any "rough" handling. Coupled with the fact that fuel is easily damaged, is the rather high economic penalty involved for any fuel which either cannot be used or causes difficulty in remote handling equipment.

The fuel assembly is likely to be worth at least $1000. This is small compared to what might be spent if the fuel became jammed somewhere between the time when it goes to the reactor and when it arrives in the spent fuel bay.

New Fuel Handling and Storage

Under normal conditions, the new fuel which is received at a generating station will be free of contamination and have such a low level of radioactivity, that it presents no hazard for any type of handling. The two main problems, then, are to prevent physical damage to the fuel which would adversely affect its future performance, and to keep correct inventory records if a large number of fuel assemblies are involved.

The first operation on receipt of the fuel will be an inspection to determine whether or not the fuel is acceptable. This will be necessary, since one shipment of fuel will ordinarily last for a period longer than the manufacturer would be willing to wait for payment, and the buyer would be reluctant to make payment until he has some assurance that the fuel is in good condition. The fuel is then moved to a new fuel storage facility, where it must be protected from damage due to personnel working in the area, and also from moisture and dirt. When the fuel is taken from storage, it should be inspected again before going to the reactor. This inspection should be even more detailed than the acceptance inspection, so that no faulty fuel is installed in the reactor. The final operation will be to load the fuel into a facility which starts the refuelling operation. It may be necessary to make records of each of these operations to keep an accurate inventory.

It is difficult to put too much emphasis on the care which must be taken in handling new fuel, since this is a routine operation, and there may be some tendency to become careless. Even damage which is not noticeable (such as a cracked weld) could have very serious consequences if it results in mechanical failure while the fuel is in the reactor or fuel changing equipment.

Reactor Fuelling

The reactor fuelling is generally carried out by one or two fuelling machines. A single machine will likely be used if the reactor channels are fuelled from one end only, but if the fuel is pushed in one end and out of the other, a machine is needed at each end. Since the machine must handle the irradiated fuel in moving it from the reactor to the fuel bay, some shielding must be supplied. This may either be built into the machine (in which case the machine is accessible) or the machine may be located in a shielded room and operated by remote control. Aside from the shielding problem, the size and complexity of the machine will depend largely on the type of heat transport system and whether fuelling is done "on-power" or during shutdown. On-power refuelling gives an economic advantage in that the fuelling costs are lower due to obtaining more heat energy from the fuel. This advantage is partially offset by the increased costs associated with an on-power machine.

Spent Fuel Handling and Storage

The main consideration in handling and storing spent fuel, is the control of radioactivity and contamination. The general principles used to control these, are to shield against the radioactivity, and to enclose the fuel in a container to prevent the spread of contamination.

The most common way of handling and storing spent fuel, is in a water filled bay or trench. (The fuel must, of course, be moved from the reactor to the bay in the refuelling operation.) About 15 feet of water is generally used as shielding, which gives a gamma ray attenuation of about 10^{10}. This is sufficient for fully irradiated fuel which has just been removed from the reactor. If the fuel is to be removed from the bay, it may be loaded under-water into a flask which is shielded with iron or lead.

If the fuel sheath has no defects, it will control the spread of contamination without further canning, but the effects of corrosion must be considered for long term storage. You will recall from the lesson on fuel, that the sheath is designed so that it is as thin as possible without too much danger of failure in the reactor. This means that there is a possibility of corroding through the sheath rather quickly if the bay water chemistry is not carefully controlled. It may turn out to be cheaper (and more reliable) to seal all fuel in heavier walled cans rather than to install and operate elaborate bay water purification systems. Any fuel which has ruptured in the reactor or during spent fuel handling should, of course, be canned as quickly as possible to prevent excessive contamination of bay water.

Since the development of reactors and reactor fuel is at a very early stage, there is considerable interest in fuel performance. One of the methods used to check the performance, is to examine the spent fuel to determine dimensional changes or defects which have developed in the reactor. It is, therefore, important that the spent fuel be handled carefully, so that handling damage does not mask irradiation changes.

ASSIGNMENT

1. Give two general results of mishandling new fuel which have a rather large economic penalty.

2. What is the main advantage of on-power fuelling and why?

3. What two main factors must be guarded against in handling spent fuels?

4. Give two affects that you feel might be undesirable if spent fuel is badly mishandled.

E.P. Horton