REGULATORY INSPECTION ACTIVITIES ON NUCLEAR POWER PLANT SITES DURING CONSTRUCTION IN THE UNITED KINGDOM

J V Jeffery

Health and Safety Executive
Nuclear Installations Inspectorate
United Kingdom

The work of regulatory inspection of the construction of the plant on the site is performed not only by the inspector who has been allocated to inspection duties for that site but also by the specialist staff who are involved with the safety assessment of the plant. The co-ordination of this work is described in the paper and examples are given of inspection activities associated with the enforcement requirements of licence conditions as well as those related to the inspection of the plant itself.

1. INTRODUCTION

To give a good understanding of the way in which regulatory inspection activities of Nuclear Power Plants (NPPs) in the United Kingdom are performed, it will be useful to describe the organisation of the Nuclear Installations Inspectorate (NII). It will be seen from Figure 1 that there are five branches of the Inspectorate which deal with, power reactors under construction, operating power reactors, fuel and isotope processing and research reactors, future reactor systems, radiological protection. The duties of inspection and safety assessment of NPPs under construction are the combined responsibility of sections a and b in Branch 1. One Site Inspector is appointed to each site and he is a member of one of those sections whose assessment duties cover pressure vessels, materials and mechanical engineering in respect of section a and instrumentation, fault studies and electrical engineering in respect of section b.

The Site Inspector is responsible for overseeing all the Inspectorate's inspection activities during the construction and commissioning stages and he becomes closely involved with the many aspects related to safety assessment. When the NPP passes from the commissioning to the operational phase the responsibility for regulatory control changes from Branch 1 to Branch 2 of the Inspectorate and it is usual at this time that the Site Inspector transfers from Branch 1 to Branch 2 to maintain continuity of the inspection activities.

2. GENERAL ASPECTS OF SITE INSPECTION

It is the practice in the UK to issue one licence only for each site and this is done at the beginning of a NPP project to enable the construction of the plant to be started, subject to certain conditions. These conditions relate to the security of the site, the construction of foundations and the bringing of nuclear fuel on to the site. They are imposed to provide a means of regulatory control over the early construction activities of the licensee. From time to time thereafter the licence is varied by the addition of further conditions and by the modification of some existing conditions as the construction, commissioning and operation of the plant proceeds. These include the provision for quality assurance arrangements, a commissioning schedule and health physics control.

When the decision is reached to licence a new NPP a Site Inspector is appointed to co-ordinate the NII's responsibilities for that plant. He will, subject to consultation with higher management and the legal department, draft the licence with the attached conditions. Thereafter he will ensure that the licence is varied as required and will re-draft the conditions and ensure that approvals are issued as necessary in the subsequent phases of the NPP. His other responsibilities are related to inspection of the site and the plant, and co-ordination of safety assessment activities, the first of which occupies the major part of his time. Before describing his inspection activities in more detail it will be useful to refer to the Site Inspector's responsibilities in relation to safety assessment.

Before appointment as a Site Inspector the individual will normally have been concerned with certain aspects of NPP safety assessment work in either section 1a or 1b. The safety assessment work is based upon the safety reports and supporting documentation submitted by the licensee.

It is augumented by discussions with the licensee and suppliers of plant, and by inspection both at site and in manufacturer's works. The Site Inspector is responsible for the overall co-ordination of the safety report information and for progressing its receipt. The inspection of plant which is associated with the safety assessment will normally be conducted by the specialist assessors, but these activities are co-ordinated by the Site Inspector to make sure they are performed in an orderly manner and the Site Inspector will usually be present for part of the time when this inspection is carried out. Inspection of a specific aspect on the site may be initiated either by the Site Inspector observing during one of his routine visits, an aspect which must be brought to the attention of the specialist assessor or it may be initiated by the assessor requiring confirmation of some other aspect which has arisen during the course of his assessment. It will be seen therefore that inspection and assessment activities in NII during construction are closely linked and this has proved to be of great benefit in providing the "two-way feed-back" of information necessary for the effective performance of both these activities. Furthermore, the linking of these activities provides a useful training ground for assessors to become Site Inspectors on future projects.

3. CONSTRUCTION INSPECTION

The specific aspects of inspection which are related to the installation of plant at the site are many and varied and it is difficult to include a comprehensive description of these activities. In general they are to ensure that the quality assurance arrangements are adequate for all safety related plant e.g. pressure vessel, reactor core construction, fuel stores, instrumentation, shutdown systems, emergency supplies etc. It would be impossible for one man to cover all these aspects in detail even if he could devote all his time to it. The approach has to be that of checking the inspection arrangements of the licensee, the construction company and the independent inspection authorities. Some examples of a few of the aspects are given in the following paragraphs by way of illustration.

3.1 Quality Assurance requirements associated with Pre-stressed Concrete Pressure Vessel Construction

The quality assurance requirements for the construction of the pre-stressed concrete pressure vessel (PCPV)are imposed by a licence condition which calls for the licensee to make arrangements for the examination and testing of all materials and components of the PCPV, which are then approved by NII. Parts of these arrangements relate to the provision of a complete record (known as the "case history") of every examination and test and to the appointment of an independent assessor (known as the "appointed engineer") whose job it is to monitor the construction of the PCPV through all its stages. The case history also includes a large number of manufacturing drawings and a photographic record of most of the internal reactor equipment. It consists of such a large amount of documentation that it is impossible for the Site Inspector to inspect it in its entirety. He does, however, discuss with the licensee, how the case history is to be compiled and carries out sample checks on its contents from time to time.

The appointed engineer is employed by the licensee's civil engineering department and is managerially outside the line of control of the

construction of the project. He visits the site regularly and is consulted on any design problem that occurs during construction and writes regular reports on all his activities, which are forwarded to NII. It may be said that, being an employee the licensee, the appointed engineer cannot be truly independent in his role. There is, however, a difficulty in finding a civil engineer who is as knowledgeable as he is independent and who is in an organisation not associated with the licensee or construction company. The problem arises from the fact that at the present time the technology of PCPV construction is still being developed and the requisite expertise is only to be found in these organisations. The independence of the appointed engineer is further enhanced by a requirement for him to consult from time to time a named consultant, eminent in the concrete technology field. In addition, the licensee is required to appoint an independent inspecting authority, usually one of the engineering insurance firms, to monitor the fabrication and construction of those parts of the pressure vessel not covered by the pre-stressed concrete technology e.g. the welding of the vessel liner and penetrations.

Thus there are a number of ways in which defects and problems may be brought to the Site Inspector's attention, from his checking of the case history, from the appointed engineer's reports, from discussions with site personnel and from advice from the independent inspection authority. Another method is from his own observation on the site and it was in such a way that the NII became aware of some significant weld cracks in the boiler liners of one of the PCPVs. The defects were caused by incorrect procedures being adopted during welding at the manufacturer's works and the Site Inspector, during the course of a routine visit, observed remedial work in progress. Recognising that the defects were in a sensitive location he was able to become acquainted with the problem in advance of the matter being reported by the independent inspection authority and was also able to involve the assessment specialist at an early stage in producing an agreed solution to the problem. Another example of the Site Inspector identifying a defect was the cracking in a section of concrete soon after it had been poured. The correct procedures had been observed on this occasion but the pouring took place in abnormally hot conditions, causing over rapid curing of the concrete with consequent cracking. Because the problem had been identified at an early stage by the Site Inspector it was possible to make special arrangements to prevent further pours of concrete being made at adjacent sections until sufficient investigations had been made into the effect of the cracks and until adequate remedial measures had been taken.

3.2 Site Inspection of Cabling Installation

The post-trip cooling requirements for AGRs are much greater than for the Magnox generation reactors which preceded them in the UK, and it was recognised at an early stage that the installation of the cabling would assume greater importance in the case of the AGRs. The integrity of the cabling depends primarily on the use of proper segregation and on adequate fire protection. Furthermore, the NPP that has a single control room for more than one reactor unit produces a cable segregation problem that is well known.

The inspection of cabling installations on the site has been carried out mainly by the specialist assessor with the assistance of the Site Inspector. No criteria for cabling have been written down to assist in

this inspection but the method has been for the assessor to develop a set of principles of cable layout and to check them against the installation on site. The cabling is so extensive that it is impossible to do a "paper" assessment of the installation and it is also impossible to check every cable. The approach has been of selective rather than random sampling concentrating on cables of major safety significance and those areas which have the highest concentrations. The NII inspectors are usually accompanied by representatives of the licensee and the construction company on such inspections and it is quite often possible for solutions of unacceptable cable situations to be decided "on-the-spot". We have been able to observe the "feed-back" of inspection taking effect in that fewer changes have been required to the cabling of the last AGR plants to be constructed.

3.3 Inspection at Contractors Works

In addition to site inspection it is often necessary to inspect plant in the course of manufacture. This type of inspection is usually related to items which are critically related to safety and which represent an advance in design or application. To illustrate these two examples of works inspection are given.

Some of the PCPVs are pre-stressed by wire wound circumferential tendons. The length of wire required for each tendon requires that the steel wire from a number of billets is joined by friction welds. The strength of each tendon relies on the integrity not only of the wire but also of the welded joints. Inspection at works was made to ensure that welding process was being carried out to specification, that sample welds were being obtained from each wire for strength testing, and that wire was only accepted if the strength of the welded section of wire exceeded 90% GUTS (Guaranteed Ultimate Tensile Strength). Quality Assurance procedures at works were thoroughly examined not only to ensure that the procedures themselves were sound but also that they were being scrupulously adhered to.

The same PCPVs have the boilers housed in pods in the walls of the vessels and each boiler penetration is sealed by a concrete closure through which all boiler services pass. Each boiler closure comprises a steel fabricated cylinder, filled with concrete and pre-stressed with circumferential wire wound tendons. Because of the novel features of this closure and its direct relevance to reactor safety, inspection was made at contractors works to check all aspects of the manufacture of the assembly, and the factory quality assurance procedures.

Much useful additional information is gained by discussion with works staff to gain an overall view of the quality of the finished product. This is useful to both the specialist assessor and the Site Inspector, both of whom normally attend such visits.

4. OTHER INSPECTION ACTIVITIES

In addition to the inspection of plant which has been referred to already in the paper, the Site Inspector is required to carry out inspections which ensure the licensee's compliance with licence conditions. These conditions place specific requirements upon the licensee and in general refer to security, authorisation of personnel, records, storage and handling of nuclear fuel, emergency arrangements, radiological

protection, design and commissioning of plant. By way of illustration, the inspection activities associated with emergency requirements, and the preparation for commissioning are described.

4.1 Inspection of Emergency Requirements

Before nuclear fuel is brought on to the site, an activity which requires specific approval from NII, the licensee is required to make arrangements for dealing with accidents and emergencies. There is a further requirement that these be demonstrated as satisfactory to NII.

The arrangements are set out in a document called the "Emergency Plan" and they include, the provision of special equipment, instrumentation, protective clothing for dealing with emergencies, liaison with local authorities, provision of communication systems and training of personnel. It is part of the Site Inspector's duty to ensure that the Emergency Plan is submitted, assessed, approved and demonstrated before he can recommend that the approval to bring nuclear fuel on site be issued.

The first demonstration of the emergency exercise is usually restricted to a demonstration that sufficient facilities exist for dealing with an emergency with the fuel in storage (e.g. a fire in the fuel store) or with fuel in transit. Later, but before the licensee is permitted to load the reactor with fuel, the emergency plan has to be up-dated to include all the emergency arrangements necessary for power operation and a satisfactory demonstration is prerequisite for the fuel loading approval. This aspect is referred to again in another paper entitled "Specific Problems and Practical Experience of Regulatory Inspection during Commissioning in the UK".

It is not possible for the Site Inspector to witness the emergency exercise alone because of the coincident activities taking place in various locations (e.g. the main control room, fuel store, district survey vehicles). To help him in his observation of the exercise the Site Inspector is assisted by other NII personnel e.g. a health physics specialist, the specialist assessor for fuel handling.

It is vitally important that emergency plans be demonstrated in as near realistic conditions as possible. While a plan may look perfect on paper and while inspections of the emergency facilities may be made to see that they exist and function correctly, it is not until all the facilities are exercised together that the failures and shortcomings become obvious and show need for correction. At the end of the emergency exercise it is usual for a 'de-briefing' meeting to take place which is attended by the NII observers, senior personnel of the licensee's staff participating in the exercise and appropriate representatives of outside bodies. The successes and shortcomings of the exercise are discussed at the meeting and conclusions are then reached as to the necessity of reviewing procedures and facilities not only on the site but also in the outside organisations.

4.2 Preparation for commissioning

The site inspection activities involved with the commissioning of NPPs in the UK are not discussed here because they are included in the paper entitled "Specific Problems and Practical Experience of Regulatory

Inspection during Commissioning in the UK". However, preparations for commissioning have to be made during the construction stage and the Site Inspector has the duty to ensure that the licensee makes the necessary arrangements for this to proceed in an orderly manner.

Certain requirements are placed upon the licensee by conditions of the licence which are:-

1. Arrangements for commissioning are to be drawn up for NII's approval.

2. A Station Commissioning Committee is to be appointed to control the commissioning - its terms of reference being approved.

3. A schedule specifying all commissioning tests be drawn up for approval, which is divided into an appropriate number of stages.

4. The licensee may not start commissioning or proceed from one stage to another without NII's approval.

It is difficult to define precisely where construction ends and commissioning starts, but the schedule referred to in 3 above is extremely useful in that it is possible to define by inclusion in the schedule, all the relevant tests over which NII wishes to have some control. The over-pressure test of the PCPV is taken to be the first important test of commissioning and by having the authority to allow this to start only when satisfied, the NII has the power to ensure that all appropriate safety assessment of the PCPV has been completed.

The safety assessment of the plant will leave certain aspects outstanding which need confirmation from commissioning tests. It is therefore possible to obtain satisfaction on this by including in the schedule requirements for the witnessing of certain tests or the provision of certain test results so that NII may check these matters before issuing the next commissioning stage approval.

The Site Inspector arranges with the licensee's staff to produce the schedule in an appropriate form and to liaise with the NII assessment staff to ensure that all necessary tests are included and that they will be properly witnessed.

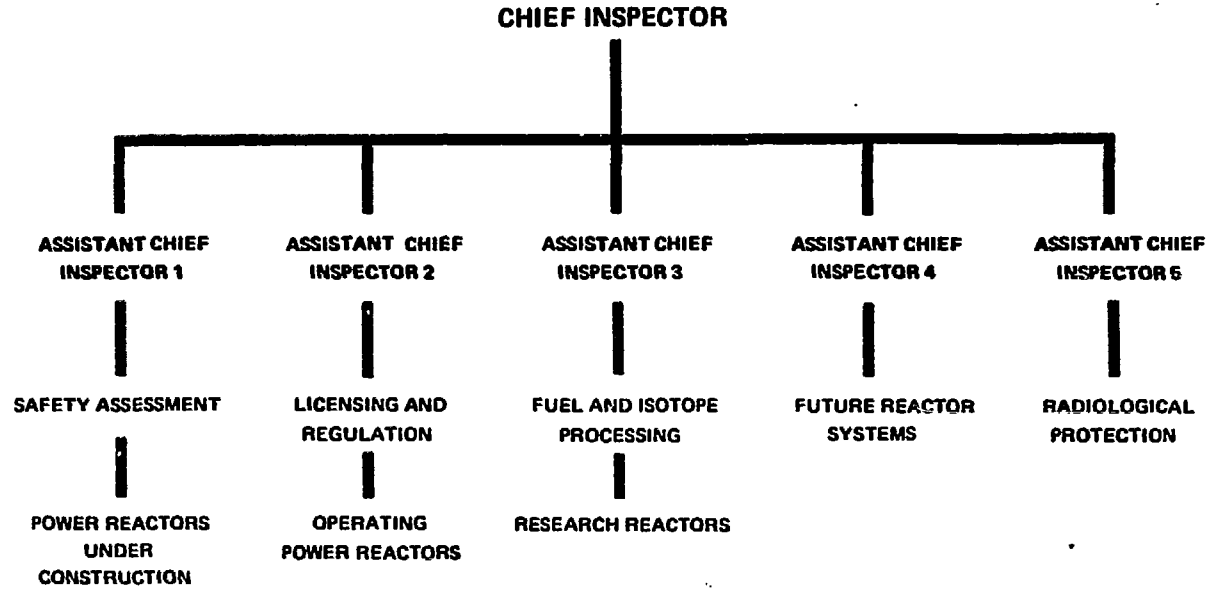
5. CONCLUSIONS

The staff organisation of NII has developed over the years from the initial arrangement of having an inspection force separate from that devoted to safety assessment, to the present organisation which combines the two functions. We have found that for NPPs during construction and commissioning, the functions of assessment and inspection are so closely related that the most effective way of imposing regulatory control is to keep the work force in one organisational unit. Separation of the two functions would require the complete codification of assessment requirements to enable the inspection staff to implement them. While it could be argued that such codification would of itself be a good thing it has not been possible to do this with the resources that are available. The present arrangement does allow staff to proceed from assessment duties, for which they are more suited when they are first recruited, to inspection

duties which can be most effectively conducted only after the staff have been in NII for some time.

The inspection requirements cover such a wide variety of plant that it would be impossible for one person to have sufficient depth of knowledge and experience to do this effectively without the aid of the specialist assessors. Furthermore the Site Inspector has to cover so many other inspection activities other than those directly related to plant. These other activities relate to licence requirements and procedural matters and involve direct personal contact with the licensee's senior staff so that the Site Inspector must have reached a certain maturity in addition to having had the requisite nuclear experience before he can effectively execute his duties.

Looking to the future we believe it will be necessary to formalise the quality assurance procedures to a greater extent, extending them to areas which are at present not covered by formal requirements. In particular the role of "Appointed Engineer" may have to be changed in order to increase his independence.



ORGANISATION OF THE NUCLEAR INSTALLATIONS INSPECTORATE

FIGURE 1