AN APPROACH TO REDUCING COST OF AN EQ PROGRAMME

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Abstract

Environmental qualification of equipment in a nuclear power plant includes a requirement to preserve the status of all qualified components. This requirement adds a maintenance burden and an expense to ongoing operations. All qualified equipment has special purchase, storage and maintenance requirements, all of which add to operating costs. Thus, it is essential that only those components with credited safety functions, which require execution in harsh accident environments, are considered for environmental qualification. Every opportunity to reduce the number of components that are to be qualified should be taken. Review of the Safety Report can often lead to the identification of components which do not have a safety function but have been included on the EQ list for other reasons. These can be removed, leading to a shorter list of components requiring environmental qualification. The list is then culled to remove components that do not have to perform a safety function in a harsh accident environment or that do not have an adverse failure mode. All revisions to the room conditions manual should be reviewed because a component that was previously considered to be in a harsh environment could now be shown as being in a mild one. In that case it could be removed from the EQL.

This paper also discusses the approach taken to perform an efficient reduction of components in an EQL (Environmental Qualification List) that was previously created using overly conservative considerations. Any removal has to be justified through auditable documentation. Since the same or similar justification can apply to many components in many systems, a generic procedure was prepared, with a spectrum of common reduction approaches.

Using this generic procedure, in conjunction with the Safety Report and the Design Manuals, allowed efficient modification of the EQL development packages. Documenting the justification for removing a component was accomplished by simply identifying the relevant methods in the generic procedure. This also ensured that all possible reasons for removal were considered.

Other possible means for reducing EQ related requirements are also mentioned.

1. Introduction

This paper discusses the ways to reduce Environmental Qualification (EQ) related maintenance costs. For new reactors, early consideration of EQ requirements and how to keep these requirements minimal will provide cost savings over the entire life of the reactor. Reduction of EQ-related costs for existing plants is not as simple as for a new plant, but opportunities do exist. One significant contributor to these costs is having too many components identified as requiring qualification. The list may have been generated from overly conservative considerations or items put on the list for non-EQ reasons. A case study is provided in which we were able to justifiably remove many components from the EQ list using an efficient process that was developed for the Bruce B Station. The process provided documented justification for removal from the list.

There are many costs associated with an EQ programme, both in development and maintenance. A comprehensive EQ programme involves:

- identification of safety, safety-related and safety-support systems,
- identification of components in the safety and safety-support systems
- identification of Design Basis Accidents which cause a harsh environment,
- establishment of normal and DBA environmental conditions,
- development of an EQ component list,
- identification of the normal operating function and the safety functions of the EQL components
- conduct of an equipment qualification and life assessment,
- procurement of qualified components and spare parts,
- maintenance of operational EQ assurance throughout station life and performing on-going EQ.

Each component requiring qualification brings with it a large and continuing cost. It is therefore important that a minimal amount of equipment is required to be environmentally qualified. Many opportunities exist for minimising the amount of equipment requiring qualification. An organised and well-documented approach is necessary to take full advantage of these opportunities.

Before discussing the methodology for reducing EQ needs, it is useful to give a working definition of Environmental Qualification.

Environmental Qualification is defined as a documented demonstration that equipment and components are capable of performing their safety-related functions when subjected to environmentally harsh conditions resulting from design basis accidents. Environmental Qualification is a subset of activities associated with equipment qualification.

EQ should only be performed on equipment that is documented as being required to mitigate a design basis accident (DBA). The function a component performs to mitigate a DBA can fall under one or more of four categories; i.e., Contain, Control, Cool and Monitor (collectively known as CCCM Functions). These functions meet the requirements of the Canadian Nuclear Safety Commission (CNSC) (formerly known as the AECB) regulatory documents, R-7 for Containment, R-8 for Shutdown Systems (Control) and R-9 for Emergency Core Cooling. The last function, monitoring of the condition of the reactor, is also essential to proper management of any accident and must be carried out until the reactor is cool and the reactor is at its safe shutdown state.

2. EQ List Development

The Environmental Qualification List (EQL) identifies equipment and components required to be environmentally qualified. Auditable documentation must be provided in the development of the EQL.

2.1 General EQL Development

The EQL development is a subtractive process. Initially, all equipment is considered. Arguments are then developed and documented to demonstrate that there is no need for EQ on certain pieces of equipment.

The first consideration is to identify the systems credited to mitigate harsh Design Basis Accidents (DBA), and then identify the associated major equipment. All other equipment is then removed. The remaining equipment thus forms the EQ Safety Related Components List (EQSRCL).

Once safety-related equipment is identified, the next step in EQL development is to consider each individual component and all of its associated components. With knowledge of the room conditions present during a Design Basis Accident, individual components can be removed on the basis that they are not required to function in a harsh environment.

2.2 EQL Development for a New Plant

The development of the EQ programme in conjunction with the design of a new plant presents many opportunities for EQL reduction or reduction of EQ-related costs.

Examples include:

- During the design, it may be possible to select a location for a component that is mild during all DBAs for which it is credited. There will be minimal expense from this action and the component does not have to be qualified.
- Also, it may be possible to select a particular design of a component so that its failure mode is to go to a safe position. Valves which are required to shut should be ones that require air or power to be open
- Optimise the number of EQ condition sets used for test/analysis (bounding curves). This requires developing a balance between qualifying some equipment to conditions harsher than necessary and the ongoing configuration management efforts that would result from having to stock equipment qualified to many different sets of accident conditions.
- Ensure safety-related equipment is not in an area subject to flooding. This is a straightforward design consideration. Locate all equipment that is required to function above the flood level.

2.3 EQL Development for an Existing Plant

EQ programmes for existing plants do not have as many opportunities for reduction as do those for new plants. As equipment is already in place, changes that would have been simple during construction may now not be feasible. It may be difficult to find a better location for equipment or the necessary services may not be readily available in the preferred location. Even with these constraints, there are still several possibilities:

- Moving components to less harsh environments. This is not as easy an activity as it is for a new design. Engineering Change Control may be onerous and expensive.
- Minimise areas subject to harsh environment by adding protective barriers or walls
- Relocate safety-related equipment outside areas of harsh environment at every opportunity

3. Potential Problems and Issues

Overall, this process must remain tightly focussed on the requirements of an EQL as derived from the definition of environmental qualification. A minimum EQL will not be achieved if operational considerations are included as justification for requiring equipment to be qualified. Only equipment that has been identified as having a role in mitigating accidents should be considered for inclusion on the list. There are usually good reasons for having equipment operate in unusual circumstances. These are not, however, generated from the requirement to protect the public from radiation exposure. A separate means of identifying such equipment should be established. In that way, its operation will be assured and it will not generate the maintenance costs of qualified equipment.

It is important to get a clear understanding of the documents to be used to decide whether or not equipment needs to be considered for qualification. The ultimate guide is the Safety Report, which is supported by the Design Manuals for each system. If operating instructions or emergency operating procedures are included in the set of basis documents, then the list may be too large and ongoing maintenance costs will be overly large.

4. Case Study for EQL Reduction

Having examined the methodology for establishing the EQL, we now discuss our experience and approach to reducing the EQL of an existing reactor. The EQL for Bruce B had already been developed, but overly conservative considerations had been used. These included conservative assumptions about room conditions, equipment added for operational reasons and equipment added for supporting Abnormal Incident Manual requirements. While the latter two reasons identify important equipment in the station, they are not necessarily required to perform a CCCM function.

There were two processes to follow to assess equipment for removal. These involved a review of the Safety Report to ensure that only EQ-related reasons for inclusion in the EQL had been used. As well, a check was made to see if there were DBAs for which credit had been taken but for which the Safety Report did not require the equipment to function. The second option was to look at the revised Room Conditions Manual, which provides the normal operating and accident conditions for each DBA in each room of the reactor. Finally, the failure modes of the equipment were considered. If the revised Room Conditions Manual showed the equipment to be in a mild environment for the credited accidents or if the equipment failures did not adversely impact the safety performance, the equipment could be removed from the EQL. Cables were considered in a different project. The Room Conditions Manual went through several revisions during the course of the project.

In this project, we had 4-6 engineers working for a period of 6-8 months. At the end, over 2500 items had been recommended for removal from the EQL. A single EQ test to establish qualification can cost over $100,000. That cost does not include the on-going costs for maintenance and preservation. The benefits of minimising the EQL are clear.

All equipment had been placed into various Function Groups (FG); i.e., groups of devices, which performed the same safety, function, as well as all of their support components. Review of each function group was then performed. In order to remove any component from the EQL, a documented argument was necessary. Wherever possible, arguments for removal were reused.

Reference material, on which arguments were to be based, included the latest revision of the plant Safety Report, the plant's Room Conditions Manual (RCM), and the Design Manuals (DM) for each system. The Safety Report documents the credited DBAs and safety requirements for the plant. It should be noted that the plant's license is granted based on this document. The RCM provides the only approved reference for the normal and accident environmental conditions of plant rooms. Design Manuals provide design and process information on the individual systems and their components.

Once arguments were formed, auditable documentation was then required to remove the components from the EQL. Two different documents were created for each FG. A memorandum was developed to justify removal based on a review of the Safety Report and system Design Manual (DM) to establish that there were more DBAs for which the equipment was credited than necessary. This first was identified as the Safety Assessment Process Memo. The current safety requirements of a function group were examined, and any unnecessary safety requirements noted. In some cases, equipment was included for which there was no safety or safety-support function. That equipment could be removed from the EQL. If there were properly included DBAs, then the equipment could not be removed from the EQL. A second document was produced which considered the failure modes and the most current room conditions. The second document was identified as the EQLDP Change Summary Memo. In this document, arguments for removal of the individual components are presented. If the equipment was fail-safe, then it did not need qualification and could be removed from the EQL. Also, often the room conditions were harsh for some DBAs, but not those for which the equipment was credited. Again, it was possible to remove such equipment from the EQL. In principle, only one of these documents is needed; however, if it can be shown that there is no credited safety function for a FG, that is preferable. Then, any change in calculated room conditions will not necessitate reconsideration.

Many reduction arguments are applicable among many function groups. Since a team of several members performed the project, tracking of arguments used was important. An electronic "boilerplate" document was developed which set out the standard format for the documents. The discussion section kept a list of previously used arguments for reduction in other function groups. The overall process is shown pictorially in Fig. 1.

A sample of the collective document produced, parts of the discussion section of the Safety Assessment Process Memorandum, is shown in the example below. The text that was collected into part of the "boilerplate" is shown with comments added in italics. Each memorandum was produced with author's and reviewer's signatures, ensuring auditability of the results. This procedure met the requirements of CSA N286.2. This master document was a dynamic entity and, as new arguments had to be developed, they would be included in the text for future consideration. A similar approach was taken to the rest of the document and for the other memorandum.

Example: Master Document Discussion Section

1. FG may be totally removed because: *(In this part, we collected the various reasons for recommending that the function group could be removed from all future consideration)*

    a) No FG safety functions for <u>any</u> DBAs *(The Safety Report did not credit the function group for any of the listed DBAs)*
        i. essential safety functions are control, cool, contain and monitor (CCCM)
        ii. essential safety functions must be documented (directly or indirectly) in the Safety Report (not in PRAs, SDMs, AIMs, etc.)
        iii. adjacent valve satisfies R-7 App. Sect 2.3, requirements for containment extension isolation. Therefore, valve has no safety function. *(Note that care had to be taken to ensure that if a valve could be removed because an adjacent valve could provide the same safety function, the adjacent valve would not be removed by the same argument.)*
        iv. Safety Report states that end shield and shield tank have no safety function (SR 3.12.1.2). Therefore temperature monitoring is not required
        v. PIFB and SIFB cooling systems are not needed as fire protection water can be sprayed on top if required (SR 3.1.5.1)

2. Reduction of DBAs for which FG must be qualified is possible because:
(There were more DBAs listed for the equipment than required by the Safety Report)
    a) No FG safety functions for <u>some</u> DBAs
        i. no CCCM function for accidents with no risk of dose to the public, e.g. LOLPSW
        ii. FG has no CCCM function for some DBAs

3. Reduction of Safety Functions for which FG must be qualified is possible because:
(The Safety Report created a requirement for the equipment to work in some DBAs, but no operation was required for some of the DBAs)
    a) No <u>active</u> FG safety function for some DBAs
        i. no change in normal operating state for some FGs to achieve CCCM (e.g. wall heat sink, metal extensions of containment, concrete or metal shielding)
        ii. metal valves located on a containment extension so that the valve body rather than the valve seat is the containment extension boundary (e.g.: MV163, MV164, MV165)

4. Reduction of Mission Time for which FG must be qualified is possible because:

(The original mission time was taken as 3 months for all equipment. In some cases, this could be reduced significantly, easing the EQ requirements.
    a) Safety function completed before 3 months
        i. Operation to CCCM completed quickly (e.g. containment isolation, dousing)

The other sections of the memorandum completed the remaining documentation. At the suggestion of the Bruce staff, we included marked copies of the relevant parts of the references and drawings used to support the discussions as an attachment. In this way, the memorandum became a complete package, which was easy to review. Team members could then quickly and thoroughly review all previously used arguments and apply any relevant ones to new function groups. The advantages included reduced time dedicated to the project, and consistency throughout the reduction process. By following this process, we were able to complete the project plus some additional work in a timely fashion.

5. Conclusions

EQ related expenses are significant and continuing. By minimising the number of components to be qualified, maintenance costs can be significantly reduced. A streamlined and consistent approach is necessary to achieve the maximum reduction and benefits.

Taking advantage of design options is also key to keeping EQ costs down. This can be easily achieved during the design phase of a new plant. Designers should be aware of EQ requirements as a part of the design process.

For existing plants, many design changes are still possible, and should be taken advantage of where technically and economically feasible.

The purpose of EQ is to provide assurance that equipment required to mitigate DBAs will function when it is required. All equipment that is part of systems designed to mitigate these accidents must be properly considered. Only equipment that has such a function should be on the EQL. Equally important, all equipment that should be on the EQL is there and none has been omitted.

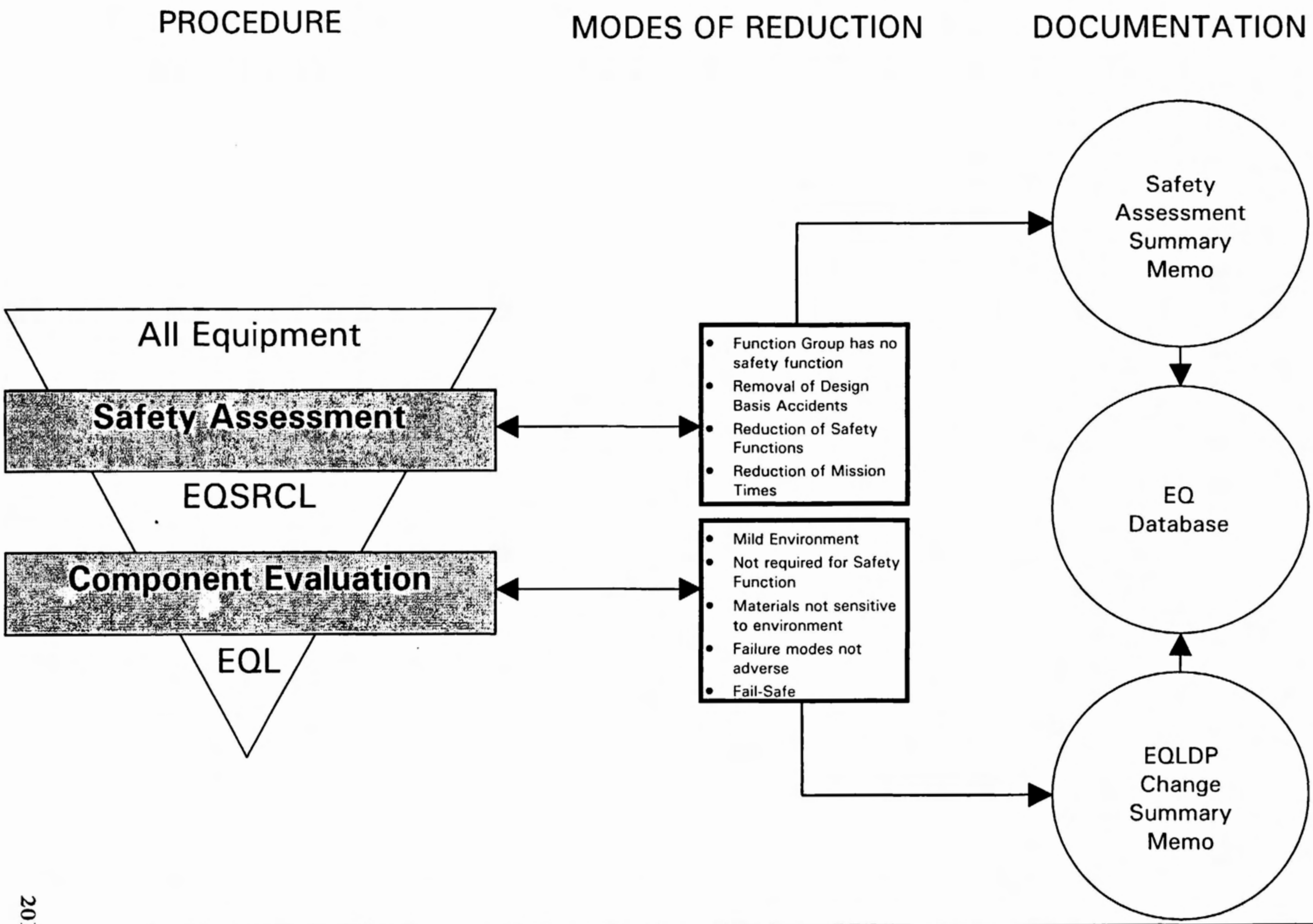

Fig. 1 - GENERALISED EQ PROCEDURE