Fusion Operating Experience Data Collection at Present and in the Future

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A gap in fusion development is the need to understand operating experiences, the reliability and maintainability of fusion-specific components in particular and high technology components in general, to be able to improve designs. Some reliability data is collected at existing fusion facilities but it is important to collect data from the next step devices such as ITER and a component test facility.

Every data collection system design must have a clear definition of the system's primary purposes. The main purposes of a reliability data collection system should be to provide the basic information for failure analysis and to allow inference of reliability parameters for components and systems [1]. This information can be used for many purposes:

- Design improvement
- Safety evaluation
- Availability improvement
- Occupational radiation exposure reduction, i.e., ALARA procedures
- Optimization of spare parts inventory
- Optimization of testing intervals for systems and components
- Optimization of maintenance planning
- Optimization of economic efficiency

Three types of data are needed for reliability and maintainability data analysis [1].
1) The first type of data is plant engineering data; that is, the system information that describes the system and its function, delineates the boundaries of the system, gives numbers of components and their functions, data on major components such as manufacturer's ratings, design environment, and component identification (e.g., unique alphanumeric identifiers for each major component), and any other information about equipment and components that comprise the system. Such documentation must be kept up to date, especially reflecting major component upgrades, component replacements, component temporary exchanges to regain system operation, etc.
2) The second type of data is component or system failure reports. These reports must be collected with attention to detail so that all faults have been accounted for and appropriately allocated to the correct system. Computerized input of the date and time that a component ceased functioning gives complete information. If a narrative field is used for engineer or operator input, the use of component identifiers is very beneficial in these additional entries.
3) The third type of data is operating reports for the fusion experiment that give the engineering data for operations – the operating campaign durations, pulses attempted, pulses performed in a time period or campaign, which systems were demanded to operate per pulse in the time period, and any other important information to assess how the systems had been exercised in a given time period

(e.g., three months, six months, a year). The data on which systems were operated for a pulse have not always been vigorously collected at existing tokamaks although computerized collection in the 2000's has improved data capture. Operations data allows reliability analysts to understand the system successes and the demands to operate plant systems, as well as the failures described in the failure reports. This third type of data is not always thoroughly documented and tends to be the most difficult to obtain from existing machines. Another aspect of the operating reports is the scheduled downtimes where maintenance and inspections are performed on the equipment and systems. Unscheduled downtimes are also important to gain information on how quickly urgent repairs can be performed. With the activities, and their time durations, recorded, these data can be tabulated and the mean time to repair (MTTR) and the inspection/surveillance times can be calculated. Data such as MTTRs and person-hours to repair a component are usually facility-specific and are generated as necessary in most industrial and power facilities. 'Craft-hour' estimates are based on the experience of the craftsmen and the maintenance history of the specific component.

Existing tokamak fusion experiments voluntarily keep track of component failures, power outages, operator errors, and other reasons that cause delays in scheduled operation. These delays are documented in brief reports. The motivation for this voluntary data collection is to promote good operations and increase plant availability and efficiency. These data reports are retained electronically [2,3] and are referred to as Trouble Reports (TRs). The TR is analogous to the internal "Plant Event Report" used in other industries to file the discovery of some degraded or faulted equipment and request preventive or corrective maintenance. The fusion TR is completed by the engineer-in-charge of operations, senior operator, or a designee in the facility operations staff. Presently, TRs tend to be very cryptic and do not always give complete information about the tokamak delay event. Sometimes the TR gives a wealth of information about a faulted component in a particular system: the method in which the component failed, how the system responded to the failure, how the component was restored to service, how long that action took, how many people worked on restoration, and the total downtime of the tokamak caused by this event. This complete TR report is desired to be collected for future reliability and maintainability analyses. While existing tokamaks may be far short of ITER systems and components, the operation of tokamak systems in a fusion environment is the best data to apply to the future steps forward in technology. For example, the performance of some existing tokamak systems will be useful to a Component Test Facility and to ITER, while other systems whose technology will not progress to future machines are of little use. Any outmoded technology is not investigated for reliability; perhaps there are some design lessons to be learned for reliability in design but those systems presently do not receive detailed analysis. Given the variability found in the voluntary TRs and the lack of regulatory influence to enforce a consistent level of report detail, for ITER an automatic, computerized data recording method for failures and maintenance is preferred for simplicity, accuracy, and completeness. The French requirements for operating data collection at an 'installation nucleaire de base' are not known at this

time. ITER RAMI data collection may well be voluntary like existing machines. With or without regulations, the engineering operations data are valuable to fusion development and must be collected.

The type 2 data should be collected using the main control system computer. The main control computer should be configured to record readings from the various sensors already in use on ITER systems; automated, accurate data will be recorded regarding system operation and system failures. The data file can record all of these data for future analysis, including the dates and times of system operation, major equipment starts and stops, and system as well as plant outages. The database should allow the engineer-in-charge or senior operator the opportunity to enter additional data into a narrative field to explain any other aspects that are pertinent to data record. Modern digital control systems can collect, store and analyze data points automatically. A typical size industrial plant, such as a phosphorous production plant in Idaho, might have 3,000 data points tracked and analyzed by a 'data historian' in the digital control system. A typical plant would have two personnel to track data submission and interpret analysis results. ITER might require one or two additional personnel since it is a large facility.

For each of the three types of data, a taxonomy to set standard terminology and standard information to include in the data set is necessary to ensure that the proper structure has been established. The taxonomy also provides for consistency and thoroughness in collecting each data entry [4]. These taxonomies should be developed for ITER so that the data can be harvested for all Parties.

For in-vessel component development, the data from neutron source testing, or component test facility, should be well documented. An issue for components tested in such a facility is to provide enough time under test so that meaningful statistics are generated.

References

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