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Preparing Equipment Specifications

19.1 THE PURPOSE OF SPECIFICATIONS

The main purpose of preparing a specification for an item of equipment is to ensure that the purchaser, who may also become the owner, obtains the equipment required, rather than what the supplier or manufacturer thinks the purchaser should have. In many situations the difference in perception of the requirements may be small and insignificant. However, for complicated equipment such as high-voltage switchgear and generation systems the differences may be very significant.

In order to satisfy both the requirements of the owner and the available options from the supplier, it is necessary to describe the requirements in various degrees of detail. The degree of detail will be a function of the type of equipment. Complex equipment such as large motors, generators, high-voltage switchgear and variable speed drive systems will need a more detailed description than the more standardised equipment such as power cables, low-voltage motors and, to some extent, low-voltage motor control centres.

Manufacturers of complex equipment regularly meet the needs of different owners, whose requirements vary in content and emphasis. A particular owner may have different requirements for the same type of equipment when it is used in offshore, as opposed to onshore, installations. These environments may be radically different, e.g. Northern North Sea, desert conditions in the Middle East, hot and humid climates of tropical locations. For example, the methods of cooling the equipment and the ability to withstand corrosive conditions will be very different in these extremes of environment.

On the other hand, simple equipment is less sensitive to extremes of location and environment. The main aspect that affects simple equipment is its full-load rating for low and high ambient temperatures. The details of the construction will be almost unaffected. Simple equipment used in high ambient temperatures will tend to be physically larger and heavier. A motor of a given shaft output rating may have a larger standard frame size when used in a desert than one used on a North Sea production platform.

A standard specification of the owner should take account of what is generally available in the market, and what can reasonably be called for as options. It is uneconomical and impractical to overspecify aspects which a manufacturer cannot fulfil at a reasonable cost and with a sensible production duration. Where possible the aim should be to match what the manufacturer can offer from his standard range of equipment. An efficient approach by the purchaser is to call for equipment that is a standard but most suitable product of the manufacturer plus the options offered, if these are

Handbook of Electrical Engineering: For Practitioners in the Oil, Gas and Petrochemical Industry. Alan L. Sheldrake
 ISBN: 0-471-49631-6

needed, and then design the power system around the equipment to be purchased. In general this will also reduce the amount of time needed to design the power system.

For some types of projects there has become an emphasis on ‘functionality’ when specifications are being prepared. Care needs to be exercised in describing functional aspects of a specification. Most people understand the function of basic equipment such as generators, motors and switchgear and yet, in order to obtain what is ultimately required, it is necessary to pay attention to design and performance details. Functionality implies a more interrelated type of existence, as is the case with systems of equipment rather than individual items of equipment. A few good examples of applying a functional approach in the specification of process control systems are SCADA systems, modern protective relaying systems, variable speed drive systems and power management control systems. These equipments comprise a system of computers, measuring devices, controller set points, switchgear and rotating machines. Here the whole system must be functionally defined, and all the individual elements must be fully compatible from the conceptual stage of the specification.

With most specifications there are some key aspects that should be clearly stated or defined, the omission of which can cause embarrassment, delay and extra costs at a later date e.g. at the factory inspection, during installation and commissioning. A well-designed data sheet to accompany the specification will do much to avoid ambiguity or the omission of requirements. The data sheet should comprise two parts, a part completed by the purchaser to define the requirements and a corresponding part for the manufacturer to state what is offered.

The content of the specification should bear a relationship to the importance of the equipment in the power system and to its capital cost. If the content is too brief or too general then it may not satisfy the intended purpose of the specification and inferior equipment may be chosen.

In summary the requirements of the owner can be arranged in the following groups:-

- Essential requirements.
- Desirable requirements. Those which may be easily available in the market as options.
- Incidental requirements. Those which would be useful but not critical to the performance of the equipment. These may not be easily available, could be described as ‘nice to have’ and should therefore be avoided.

19.2 A TYPICAL FORMAT FOR A SPECIFICATION

The following format is reasonably typical of an equipment specification. Owners and purchasers, of course, have their particular style and preferences as to the order in which the paragraphs and clauses are placed in the specification document.

- Introduction.
- Scope of supply.
- Service and environmental conditions.
- Compliant international standards.
- Definition of technical and non-technical terms.
- Performance (or functional) requirements.
- Design and construction details.
- Inspection and testing.

- Spare parts.
- Documentation.
- Packing and transportation.
- Appendices, if necessary.

19.2.1 Introduction

In this introductory section there should be a brief description of where the equipment is to be located, what type of installations will use the equipment and whether the environment is hazardous or non-hazardous (or both).

19.2.2 Scope of Supply

A summary listing should indicate all the main components that constitute the equipment, e.g. AC generator, coupling, exciters, AVR, terminal boxes, lubrication system, stator cooling system, heat exchangers.

Where appropriate it is prudent to describe or list what is not included in the scope of supply. This will minimise misunderstandings at a later stage when quotations are being compared, e.g. for the above example, gearbox, prime mover, base frame or skid assembly.

19.2.3 Service and Environmental Conditions

Here should be explained the range of environmental (ambient) temperatures, humidity, winds, and available cooling water conditions. The design ambient temperature should be stated. The type of weather throughout the year may have an influence on the design of the equipment, e.g. dust-laden wind, heavy storms, corrosive rain, air contaminated with chemicals. Outdoor and indoor conditions should be described if appropriate.

19.2.4 Compliant International Standards

A list of only the most appropriate international standards should be included. The title, identification number and latest revision number should be given. If too many standards for the type of equipment are listed, then much confusion can arise at a later date when the quality assurance checks are made. Some standards have similar titles but have subtle differences and applications. (Mixing European and US standards can give rise to misinterpretations of their definitions and suitability as they are not necessarily identically equivalent to each other, such as in the case with some BSI and IEC standards that meet the CENELEC harmonisation norms.)

19.2.5 Definition of Technical and Non-technical Terms

When it is proposed to issue an enquiry for the purchase of equipment on an international basis, it should be borne in mind that the interpretation of words and phrases, which may not be in regular use by the recipient, can suffer through translation. Some of the international standards, e.g. IEC60034, 60050, 60079, include sub-sections or clauses for defining words, phrases and terms. Sometimes these definitions are not easy to grasp.

It is recommended that particularly important words, phrases, terms and abbreviations are defined in the specification itself, especially if they differ in use from say those given in an IEC specification. (An example that regularly appears is the difference in meaning between 'shall' and 'should'.)

Some of the material in this section could equally well be placed at the end of the document as an appendix.

19.2.6 Performance or Functional Requirements

Somewhere in the specification, or the data sheet, should be stated the expected life duration of the equipment, e.g. 25 years, and a reasonable duration of continuous service between major maintenance operations, e.g. 3, 4 or 5 years. These durations will depend upon the type of equipment, but for major items such as large generators, large high-voltage motors, switchboards, motor control centres, power transformers, these durations can be regarded as typical for the oil industry.

If equipment is to be specified for use in hazardous areas, e.g. Zone 1, Zone 2, then the equipment as purchased should not have been modified in any manner that could invalidate its hazardous area certification. Components that can be vulnerable to modification are terminal boxes, gland plates and threaded entries.

The basic requirements for performance can be categorised as follows:-

- Starting up.
- Normal continuous operation.
- Permissible but limited overloading.
- Short-circuit withstand.
- Shutting down.

It will be useful to the recipient to have an understanding of the power system or network into which the equipment will belong. This is especially important when specifying the high-voltage generation and distribution equipment, and some of the main low-voltage equipment such as switchgear. The modes of operation of the power system may have some bearing upon the design of the equipment being specified, e.g. method of earthing neutrals, minimum and maximum fault currents, dips in system voltage and frequency, normal and abnormal switching configuration.

The owner may have some restriction on how to start up and shut down equipment, e.g. limits on starting currents of motors, voltage dip limits at switchgear, duration of start up or shut down, purging with safe air or inert gas, interlocking schemes, manual or automatic sequences.

For some equipment, especially generators and their prime-movers, the normal or rated duty may need to be emphasised so that the correct rating for the prime-mover is chosen, and an adequate margin for short-term permissible overloading exists. Emergency generators used offshore may need to be allowed to run in overloaded conditions until they run out of fuel or actually fail. International specifications should be referred to for the description of full-load duty for particular types of equipment, for example IEC60034 for generators and motors and for switchgear see sub-section 7.1.

If equipment needs to function continuously in high ambient temperatures, e.g. 40°C or higher, then the derating of the manufacturer's standard equipment should be quoted and explained by the manufacturer. This is especially important with switchgear busbars and circuit breakers. Some manufacturers may not wish to quote for high ambient conditions, and many of the international standards use 40°C as their upper limit.

The short-circuit withstand performance may be important with certain types of equipment, e.g. generators, high-voltage motors, switchgear, power transformers. This should be described or stated in the data sheet. The rms and peak values of short-circuit currents may need to be described.

Some equipment may be sensitive to unbalanced loading, unbalanced supply voltages or the harmonic content of the supply.

19.2.7 Design and Construction Requirements

Oil industry equipment tends to be more robust than normal industrial equipment due to the often harsh and hostile environments in which it is expected to function without trouble for long periods of time. The indirect cost of equipment failures and outages is high and reliability is of paramount importance.

An essential requirement is the definition of the degree of protection of the enclosure for the environment, which may be either outdoor or indoor, and hazardous or non-hazardous. The international standards most often used are IEC60529 and NEMA-ICS1-110 for the degree of protection against liquids and particles. These references are applied for the hazardous area protection. See also Chapter 10.

Wound components such as motor and transformer windings need to have their insulation specified to withstand the surface temperature of the copper conductors. IEC60085 and ANSI/NEMA describe the different classes of insulation that are normally available. Where IEC60085 or ANSI/NEMA is the reference, the two most common are Class B and Class F. These state the maximum temperature rise in degrees Celsius above the conductor temperature when the temperature of the cooling medium for the equipment is no greater than 40°C.

For most equipment ratings used in the oil industry the temperature rise limits are 80°C for Class B and 100°C for Class F (Class H allows 125°C). It is common practice to specify Class F insulating materials but to restrict the actual temperature rise to that of Class B. These stem from the recommendation in IEC60085 that for ratings equal and above 5000 kVA or if the iron core length is equal and above one metre, that this combination of classes should be used.

Various IEC standards for switchgear refer to IEC60694 sub-section 4.4.1 for the requirements of rated current and sub-section 4.4.2 for temperature rise of enclosed components such as bare terminals, busbars and risers, panel surfaces, and built-in apparatus. It also refers to IEC60085 for the classes of insulation. Busbars and risers can be bare or insulated and so it is not practical to state a requirement for their temperature rise in the project specification.

The owner may have particular requirements for the materials to be used for insulation and their impregnation. This may be due to their experience with marine and highly humid environments.

Other aspects that should be included are protective devices, measurement detectors, terminal blocks, segregation of circuits and terminals, voltage surge suppression, skid construction, floor frames, lifting eyes, jacking points, earthing bosses, indicating devices, control switches, automatic voltage regulators, exciters, detachable panels and doors, forced cooling, shaft bearings and seals, lubrication systems, anti-condensation heaters, noise levels, labelling and nameplates, painting etc. Some of these may be efficiently included in the data sheet.

19.2.8 Inspection and Testing

Inspection and testing of the purchased equipment is one of the most important tasks in the engineering of a project. Its importance is sometimes underestimated. The first serious tests that the purchaser will witness are those in the factory where the equipment is assembled. These tests will also include a physical inspection of the equipment.

It is therefore important to state clearly in the specification what inspection and testing will be required and, where appropriate, what are the acceptable limits of the results. Most tests required in the oil industry are covered in international specifications and these can be used as references. However, not all those in the reference documents need to be carried out in all cases. It is therefore prudent to state the requirements in the project specification in one or more of the following methods:

- Write a detailed description of exactly what is required, including the limits that are acceptable and the form in which the results should be reported. This method ensures a 'self-contained' approach that is very beneficial during the actual testing operation. Often time is limited to perform tests and to have all the requirements to hand without having to search through related documents enables the work to be completed very efficiently.
- Quote the exact clause numbers and sub-section headings in the reference documents for the particular tests to be performed. This may be less efficient when the time of the tests becomes due, especially if the reference documents are not easily to hand. If a statement is made such as 'the switchgear shall be tested in accordance with the XYZ-123 international standard' and no other clarification is included, then many debates can arise at the time of testing.

Whichever method is used it should be carefully checked by a quality assurance department before the specification is approved for purchasing the equipment.

Some types of equipment require 'production tests', 'type tests', 'performance tests', 'routine tests', 'abbreviated tests' or 'special tests', or a combination of these tests. The subtitles are sometimes used with different meanings. Production tests are required for complex equipment such as high-voltage generators and motors, and these tests are performed in the factory before the complete unit is assembled. For example the rotors are balanced without the stator, air-to-water heat exchanges can be tested to withstand hydraulic pressure, winding insulation and individual coil insulation can be tested.

Type tests are performed on one from a group of identical units. These tests are comprehensive and some of which are usually only performed once in the life span of the equipment.

If the equipment is a standard product of the manufacturer for which existing certificates can show that a type test has previously been carried out, then the purchaser may wish to accept the certificate without repeating the test. This is largely a matter of choice than necessity.

Routine and abbreviated tests are generally the same form of tests. These are applied to those units in a group that have not been type tested. If only one unit is to be purchased and a type test has been waived then a routine test is usually performed and the results compared to those of a previous type test. The number of different tests included in the routine tests is less than that of the type tests.

Some of the tests may be identical in each category. Routine tests are usually witnessed by the owner or purchaser.

Performance tests are those tests that need to be carried out on combined equipment such as a gas-turbine driven generator or a pump driven by a high-voltage motor. In such cases the dynamic relationship between the various equipments is of interest. For example, rotor vibration, critical speeds, run-up time to full speed, starting up and shutting down sequences, full-load and over-load performances, heat dissipation and cooling medium performance.

Occasionally 'special tests' may be required. These may be due to the need to operate the unit in an unusual mode or to test special control systems that may involve associated equipment such as a power management system or a control panel. Special tests may be needed to verify the operation of protective devices in the equipment rather than the equipment itself, but which require the device to be in its fully functional position on its host equipment. The owner or the purchaser usually witnesses performance and special tests.

Routine tests usually include a thorough inspection of the equipment both before and after the testing is complete. Routine testing should not be confused with sample testing. For example a switchboard may consist of many panels of essentially the same type, e.g. motor starters, transformer feeders. The testing schedule should state whether samples of similar types could be tested in lieu of testing all the units. In either case a full routine test is generally required. Functional testing of mechanical operation should be applied to all the units, e.g. open and close contactors, rack in and out circuit breakers, operate switches and controls.

19.2.9 Spare Parts

At the inquiry stage it is common practice to ask the manufacturer to list or describe what spare parts are needed for commissioning purposes and for normal use of the equipment.

19.2.10 Documentation

For equipment such as generators and switchgear the documentation can be extensive. Some of it is needed by the project design engineers as soon as possible after the purchase order is placed. The delivery of documentation can be made at the following basic stages:-

- Tender documentation.
- Purchase order documentation.
- At the time of delivery of the equipment.

Documentation can be divided into drawings and documents, some of which are listed in Appendix E.

19.2.10.1 Tender documentation

The following dimensional drawings would normally be required at the tendering stage of a project, so that comparison can be made between the various tendering manufacturers,

- Plans and elevations of the main structure.
- Base frame or skid dimensions.
- Attached equipment such as heat exchangers and ducting.
- Location of fitting eyes and jacking points.
- Cable box positions.
- Cable gland plate positions.
- Nameplate details.
- One-line diagrams.
- Typical schematic diagrams.
- Control and logic diagrams.

In addition, the following written documents would normally be required,

- Completed data sheets.
- Quality assurance plan and procedures.
- Inspection and testing plan and procedures.
- Detailed list of performance, type, routine and special tests.
- Hazardous area certificates and certificates of conformity, see Chapter 10.
- Spare parts list.
- List of attached equipment, e.g. anti-condensation heaters, temperature detectors.
- Heat dissipation of units.
- Weight of each major component, e.g. heat exchangers, rotors, stators.
- Copies of existing type tests certificates.
- Reliability data, e.g. mean time before failure.

19.2.10.2 Purchase order documentation

After the tendering process has been completed and an order is about to be placed the following documents would be required as soon as possible,

- Revised versions of the documents submitted at the tender stage.
- Completed data sheets.
- Foundation loading details.
- Lubrication system details.
- Rotor removal and replacement procedure.
- Full details of all cable termination, gland plates and boxes.
- Lay-down area adjacent to the equipment.

- Detailed list of spare parts.
- One-line diagrams, schematic diagrams, block diagrams etc., for the specific equipment being purchased.
- Functional narrative descriptions of start up, normal operation and shut down.
- Interconnection diagrams.
- Schedule of controls, alarms and event messages.

19.2.10.3 At the time of delivery

Before the equipment is delivered to the site it will normally undergo the type and routine tests in the factory. These tests are often referred to as the factory acceptance tests (FAT). Some documents are required before the FAT and others afterwards. Those required before are usually the inspection reports as part of the quality assurance plan, instruction manuals for transportation, storage, installation and commissioning routine maintenance.

After the FAT is complete the purchaser would normally require the testing report and a set of revised drawings.

19.2.11 Appendices

Appendices may be needed to give particular details, e.g. hazardous area applications, testing data, special tests, bearings and lubrication requirements, noise information, protective relay data, interlocking requirements, switchgear cubicle contents, control panel requirements, and copies of partially completed data sheets.