TURBOMACHINERY SPECIFICATIONS

by

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ABSTRACT

This paper outlines the American Petroleum Institute specifications that are available for turbomachinery, and presents information on how these industry specifications are prepared and modified. The advisability of individual company specifications, supplementing those of the API, is covered. Further, the specification areas requiring decisions by the Purchaser for each specific application are reviewed: these include type of driver, control system, equipment orientation, materials requirements or limitation, equipment details such as casing and impeller construction and seal and coupling type, oil system arrangements and features, required instrumentation, degree of testing, and drawing and data requirements. The importance of safety considerations for each specific application, including the increasing problem of noise level, is reviewed. Finally, a workable "purchasing" procedure is presented.

INTRODUCTION

A "Specification" for a compressor and driver conceivably could vary from the simple statement "Vendor shall furnish a compressor and driver" to an elaborate, lengthy, restrictive, and detailed document. Obviously, the vendor could not furnish suitable hardware with the only instructions available being "furnish a compressor and driver." Certain basic information, at least, is required such as capacity, pressures, type of gas, type of driver, site conditions, utilities conditions, etc. Additional information can and should be included, the amount being dependent on many factors. A specification is a formal communication document between the purchaser and the vendor, and the most satisfactory end result will be obtained when a clear and precise understanding exists between the two parties.

Before proceeding, it might be interesting to see how Webster defines the term "Turbomachinery Specifications." A check of the dictionary shows that the complete term is not defined. However, a valid definition can be developed by combining the definitions of the component words. "Turbo" is defined as "coupled directly to a driving turbine" or "consists of or incorporating a turbine." "Machinery" is defined as "machines as a *functioning* unit." "Specification" is defined as "the act or process of identifying or making specific through the supplying of particularizing detail" or "a detailed, precise, explicit presentation (as by enumeration, description, or working drawings) of something or a plan or proposal for something, as a written statement containing a minute description or enumeration of particulars." The term "minute" in the above can be defined as "of very small importance or consequence, trifling, petty" or "marked by close attention to and meticulous exactness in the treatment of very small parts or details:" equipment users emphatically reject this first definition and insist on the validity of the latter. By putting the pieces together a definition of the term "Turbomachinery Specifications" can be stated as follows:

> "A detailed, precise, explicit presentation, marked by meticulous exactness in its treatment, covering machines as functioning units which are coupled directly to and incorporate a turbine driver."

Thus, turbomachinery includes radial and axial flow compressors, steam and gas turbines, intermediate gear units, and necessary auxiliary equipment such as oil systems, couplings, and integral controls and instrumentation.

API EQUIPMENT SPECIFICATIONS

The American Petroleum Institute, or API, has the following turbomachinery specifications, which meet this definition, published and available:

API Standard 611—General Purpose Steam Turbines for Refinery Services

API Standard 612—Special Purpose Steam Turbines for Refinery Services

API Standard 613—High Speed Special Purpose Gear Units for Refinery Services

API Standard 616—Combustion Gas Turbines for General Refinery Services

API Standard 617—Centrifugal Compressors for General Refinery Services

In addition, a new API Standard, 614, has been prepared and approved for publication covering lube and seal oil systems. Further, a revised draft of API 617 will be published in the near future.

These API equipment specifications are prepared and periodically revised by the Subcommittee on Mechanical Equipment, with assistance from engineering contractors and manufacturers. The members of the Subcommittee on Mechanical Equipment are equipment specialists from oil and petrochemical companies and for the most part they have substantial experience in this field. The Engineering contractors are represented by their equipment specialists and are organized as a separate subcommittee reporting to the Subcommittee on Mechanical Equipment. A separate manufacturers' subcommittee exists for each equipment category such as steam turbines, gas turbines, centrifugal compressors, and gears. The manufacturers' representatives are experienced engineers with current assignments in design, application, or marketing. Thus, a wide range of background and talent is utilized in the preparation of the API equipment specifications. I strongly recommend that these API standards be used as the basic specifications for your future turbomachinery.

SUPPLEMENTAL SPECIFICATIONS

Industry type specifications, such as the API equipment standards, cannot be completely definitive in many areas for a number of reasons. For example: Complete accord cannot be reached on many sections of the specifications and compromises are required: philosophies of individual companies regarding specific details and equipment requirements vary: and each job or project requires a certain amount of "tailoring" of any general specification.

The required supplemental specifications can be handled in two ways, as follows:

1. Individual company specifications incorporating, modifying and amplifying API specifications plus minimal job specifications.

2. More comprehensive job specifications incorporating, modifying, and amplifying the API specifications.

The former arrangement generally is preferred and recommended since adequate time often is not available during a specific job to give proper consideration to all aspects of the specifications. Also, with general specifications available the vendors can become familiar with each company's philosophy and requirements, thus resulting in more acceptable quotations in a shorter time period. A valuable communication document, which should be an integral part of the specification, is the Data Sheet. Each API equipment specification includes a recommended Data Sheet. Considerable time and effort has been put into the format and content of these data sheets, by the refiners, contractors, and manufacturers, and I urge that these standardized forms be used with minimum changes. You will find that these data sheets are quite comprehensive, covering pertinent aspects of the application and equipment details. The data sheet for centrifugal compressors, for example, consists of 6 pages, and covers process requirements, compressor construction features, lube and seal oil system details, instrumentation, inspection and tests, weights, winterization, utilities, and a driver summary. Those preparing specifications should be sure that the written specifications and the data sheet information are consistent; contradictions lead to confusion, delays, and often extra charges by the vendor.

PURCHASER DECISIONS

Regardless of the amount of detail contained in general specifications, API or otherwise, many decisions must be made by the Purchaser for each specific job. Some of these can be made in advance and included in the general specifications whereas others are strictly job oriented. Table 1 presents a listing of the usual Purchaser Decision items that should be resolved to finalize a specific job specification.

TABLE 1.
PURCHASER DECISIONS

GENERAL	
1. Layout	Grade or mezzanine mounted; nozzle orientation; oil system(s) location; accessibility requirements.
2. Arrangement	Single or parallel units; direct connected or geared; allowable number of connected casings; baseplate or soleplate mounting; maintenance handling.
3. Environment	Indoor, shelter, or outdoor; degree of dust, rain, etc.; winterization requirements; temperature range.
4. Type of Compressor	Centrifugal, axial, rotary or reciprocating; speed limitations if any; uncooled or intercooled.
5. Type of Driver	Steam turbine, gas turbine, or electric motor; geared or direct connected.
COMPRESSOR	
1. Operating Conditions	Normal and rated conditions; operational variations; projected run length; gas composition(s); corrosiveness of gas.
2. Casing	Horizontally or vertically split; steel, ductile iron, cast iron or other material; cast, forged, or fabricated; vent and drain requirements.
3. Impellers	Semi-open or closed; material; welded, riveted, or milled; hardness limitation.
4. Seals	Labyrinth, contact, or liquid film (bushing), separate seal oil system or common with lube systems; type of labyrinth seal auxiliary system.
5. Couplings	Dry membrane type or lubricated gear type; grease packed or continuous lube; close coupled or spacer.
6. Lube Oil System	Single or multiple systems; pump and driver types and arrangement; number of filters and degree of filtration; type and extent of instrumentation and control; single or twin coolers; supply water specifications and allowable temperature rise.
7. Seal Oil System	Integral with or separate from lube oil system; overhead seal oil tanks or differential pressure controller; float operated drainers or collecting pots with control valves; plus same items as for lube oil system.

8.	Basic Control Scheme	Pressure or flow control; control by speed, suction throttling, discharge throttling, or by-pass; integral inlet guide vanes or external throttle valve.
9.	Instrumentation	Hydraulic, pneumatic, or electronic control; panel or local mounted instruments; coverage and quality of instrumentation; vibration monitoring equipment requirements.
10.	Testing	API basic test requirements only or additional testing; closed loop performance, driver, and/or auxiliary equipment test requirements.
11.	Drawing & Data Requirements	For record only or for approval; number of copies and timing requirements.
12.	Steam Turbine Drivers	General or special purpose; steam conditions including variations; operating horsepower and speed range requirements; single or multivalve construction; carbon ring or labyrinth packing; integral or built-up rotors; type and degree of instrumentation.
13.	Gas Turbine Drivers	Type of starting and/or helper unit; starting torque requirements; single or two shaft unit; manual semiautomatic, or automatic start-up; type and quality of inlet filter and silencer; exhaust gas heat recovery facilities; type and degree of instrumentation.
14.	Electric Motor Driver	Electrical characteristics; type of motor enclosure required; starting torque characteristics and requirements; instrumentation requirements.
15.	Gear Units	Hardness, noise level, and service factor limitations; instrumentation requirements.

NOISE LEVEL

Noise level has received increased attention by manufacturers, designers, and users since the establishment of Federal regulations regarding exposure by employees. Paragraph 1910.95 of the May 29, 1971 Federal Register, Volume 36, Number 105 (which contains Occupational Safety and Health Standards) states:

> "Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table G-16 when measured on the A scale of a standard sound level meter at slow response."

Table G-16, Permissible Noise Exposures, is as follows:

Duration/Day, hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

In view of these regulations the user has the following choices:

1. Provide a working environment with a maximum noise level of 90 dBA.

2. Monitor and control the exposure time of employees if the noise level exceeds 90 dBA.

3. Provide protective equipment for employees when the noise level exceeds 90 dBA.

Obviously, the preferred approach is to provide a working environment with noise level under 90 dBA. This, however, is not easy to achieve in process facilities because of 1) the lack of detailed information by the manufacturers regarding generated noise levels and frequencies, 2) the compounding of noise level when multiple units exist in an area, and 3) the cost associated with effective sound reduction or limitation.

To further complicate the problem, many state and/or local governmental bodies have to contemplate peripheral and neighborhood noise limitations. These may be the dominant criteria that make noise reduction mandatory. There appears to be no standard solution to this problem. Each plant and each facility will have to be handled individually, recognizing probable exposure time, location, existing or probable local regulations, etc.

SAFETY ASPECTS

Equipment specifications should reflect the specific safety aspects related to the total process unit. These include the following:

1. On automatically controlled variable speed units, should the unit slow down to minimum governor speed or speed up to maximum governor speed on loss of control signal? The effect on the process unit usually will dictate the desired action.

2. How extensively should automatic trips be applied? Many factors, such as the effect of a trip-out on the process unit, degree of operator attendance, probable damage if the compressor unit is not tripped out, etc., should be considered.

3. Can any oil be tolerated in the process gas stream? In some instances even a trace of oil in the gas stream from bearings or seals can be hazardous. In other applications oil in the gas stream can affect the performance of the process unit. In these cases the compressor design must be such as to positively avoid the entrance of any soil.

4. Can any air be tolerated in the compressed gas stream? Labyrinth seal arrangements often inject some air into the process gas system and it may be necessary to avoid this arrangement.

5. How serious is gas leakage through the seals and how long will it take the unit operators to close valves and isolate the machine? Consideration of these factors may dictate the type of seal and seal system to be used, including the size of the overhead seal oil tank for bushing type seals.

RECOMMENDED PURCHASING PROCEDURE

Specifications can and often are interpreted differently by various people. Further, specifications usually cannot cover all details of a compressor-driver-auxiliary package, particularly when alternate designs or details are involved. Consequently, a procedure should be followed, starting with the inquiry specifications, that will

result in a clear understanding between the vendor and purchaser of the details of the equipment to be furnished. The major steps of a recommended workable procedure, from the job beginning to equipment shipment, follows:

1. *Preparation and Issuance of Inquiry Specifications by Purchaser.* Careful attention to completeness and accuracy of the inquiry specifications results in a high probability of the initial proposals being acceptable. The specifications should include all requirements, features, and auxiliaries that are considered mandatory by the Purchaser.

2. *Preparation and Submittal of Proposal by Vendor.* The vendor's proposal should completely describe the equipment to be furnished, including any alternate proposals. A data sheet, completed to the degree practical, should be included. From the Purchaser's standpoint, the proposal should include a specific statement that "the proposal is in accordance with the job specifications," with any exceptions listed and explained; this avoids having the Purchaser make a detailed check regarding conflicts within the proposal and between the proposal and the specifications.

3. *Pre-order Review of Proposal with Vendor.* Prior to placing the order, it is highly advisable to have a detailed review of the proposal with the vendor. Alternate designs and details can be accepted or eliminated, "typical" drawings can be clarified as related to the specific job, and in general a common understanding between the Purchaser and Vendor can be established. Any changes, agreements, etc., should be documented.

4. *Preparation and Submittal of Revised Proposal.* Usually sufficient changes are developed during the pre-order review to justify a revised proposal. The revised proposal should be tailored to cover the specific equipment that is to be furnished; all alternates and extraneous material should be committed. This may seem like an unnecessary step, but experience has shown that it avoids errors and confusion during the job.

5. *Engineering Coordination Meeting After Order Placement.* As soon as practical after placement of the order, usually 4 to 8 weeks, an engineering coordination meeting should be held in the manufacturers' engineering offices. The driver manufacturer also should attend this meeting. Preferably the Purchaser should come prepared with his contemplated layout of the equipment-nozzle orientation, oil system location, elevations of main equipment and auxiliaries, control panel location, etc. Preferably the manufacturer should have preliminary drawings of the composite outline and auxiliaries and the schematic drawings for the lube and seal systems. A review of and agreement on these basic drawings are the critical steps in the prompt and proper execution of the project. A properly handled and documented coordination meeting can avoid many job delays, drawing revisions, and arguments regarding contract extras. The meeting should include the development of a realistic drawing and data schedule. The meeting should be documented promptly and incorporated into the formal order.

6. *Drawing Review.* Issuance of drawings per the job schedule and prompt review and return by the Purchaser are required if schedules are to be maintained both by the manufacturer in his shop and the Purchaser in the field. Prior to issuance the manufacturer should be sure that the drawings reflect the job specifications. The Purchaser's comments also should be based on conformance to specifications. Changes should be held to a minimum if job delays and contract extras are to be avoided.

CLOSURE

Specifications are the contractural communication from the Purchaser to the Manufacturer. However, until a firm and final agreement is reached between the Purchaser and the Manufacturer, specifications should not be considered "sacred." A free and open interchange between the parties involved will result in the most realistic specifications on which to proceed.