PROCESS SPECIFICATIONS

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Today, radomes are used almost exclusively by the Military. This being the case, all requirements of the governing military specifications must be observed along with all those of the individual prime contractors -- the aircraft manufacturers. Occasionally, a potential fabricator may be awed by what may seem to him to be an overwhelming set of specification requirements. These requirements need not be "merely" burdensome, but may serve many useful purposes for the fabricator. We will discuss one requirement, that of preparing process specifications, and indicate some of the useful features which process specifications may possess.

Type and Scope:

Each of the specifications covering radomes and the materials which go into their manufacture requires of the radome fabricator a process specification which is to describe details of manufacture and control of process variables. Done properly, the preparation of specifications can be a time consuming job; however, again done properly, the specification is a very useful document. Thus, we have an alternative between a specification which serves only to comply with the required formalities or one which is well founded on sound engineering and manufacturing practice and, as such, is a ready reference for all phases of part design, planning, and production.

Once the course to be taken has been decided, a fabricator has the choice of preparing two types of specifications. First, he may prepare a specification for each part which is to be manufactured. In this case the task is simplified in that normally only one resin, one type of core material, one method of construction, etc. are employed. The disadvantage of the "part specification" is the large number of documents which will be required. The second choice is to prepare one set of specifications which can be assembled into a manual which will cover all phases of production for all types of parts. In this case, obviously, the specification for each phase must necessarily embrace all variations in the process which can be anticipated. Since the variations and combinations thereof are almost infinite, some degree of standardization must be employed.

Zenith has chosen the latter alternative of the large-scope specifications. Exhibit A, the index to Zenith's specifications, shows the field covered by these specifications. Each of the individual specifications normally contains several variations in procedures. In order to minimize the variations while maintaining the required quality levels, all processes have been established to provide optimum part characteristics. For example, the various cycles of postcure for certain of the high and intermediate temperature range resins could be all but innumerable, but the postcure which has been determined by test to provide maximum

properties is selected. Regardless of how low the stress levels of a part are with respect to the calculated allowables, the postcure which provides the maximum properties is selected. Carrying this standardization further, the designer and production planner will have only one resin and cure system to choose which will fulfill the requirements of the job at hand. Still further, with a given set of part requirements, tooling and production facilities, only one material or combination of materials and one process will be selected for the job. In this way the myriad material and process variations available in the reinforced plastics field are conveniently reduced so that the best combination for a job is chosen in much the same way as the metal working industry can call out a certain alloy or heat treatment.

Form and Usage:

If the specification is to accomplish the purposes previously set forth, there are definite requirements for the information it must contain. Exhibit B, which is extracted from the Introduction to Zenith's Manual of Specifications, establishes the general form for the specification and the information it is to contain. The materials and equipment call-outs are necessarily generalized since it often happens that a customer will supply his own tooling or at least he will specify the type of tooling to be used. Also, the customer will in many cases specify the materials to be used in his part. Obviously, in these cases the customer requirements take precedence over Zenith specifications. In the absence of such limitations, however, the call-outs of the specification are useful for planning. Certainly the detailed procedures section is useful to both Planning and to Manufacturing superintendents and leadmen.

The usage of the specifications is probably best described by discussing its use by different departments in the complete cycle of manufacture of a hypothetical part. Following the invitation to bid, the Estimating Department will prepare a cost estimate. Preparation of estimates can be assisted by reference to specifications for time estimates. Also, in those cases where the type of construction is left open, the estimator often obtains useful information by consultation with the specifications and with personnel of the Materials and Process Group, under whose jurisdiction the specifications are prepared at Zenith. Upon award of the contract the design engineers start their work. The drawing for the part will reference the Zenith Process Specification 1A-1000 (the Specification Manual code number) for all phases of fabrication, inspection, etc. By this reference the designer has tied down the job to certain processes and materials. It must only be decided then whether the part is to be void-free, which resin and glass are to be used, and so on. The Engineering Stress and Structures Group will determine what construction is optimum for a given set of requirements.

The next department concerned is the Manufacturing Planning Department. Working from blueprints, the planner prepares a detailed operation sheet or manufacturing outline. It is here that the Process Specification plays an important role, for the planner may call for an operation merely by referencing the appropriate specification code number. In this way, detailed procedures are not needed on the operation sheet. One significant step in the direction of eliminating planning detail at this level has been accomplished by establish-

ing catalytic systems for resins and assigning code numbers thereto. These catalytic systems have been worked out according to type of cure to be used, speed of gelation desired, and other such considerations. The appropriate catalytic system is entered on the manufacturing outline and the production personnel obtain the correctly catalyzed resin by requesting the listed code number. By this procedure, resin catalysis is completely standardized and we can be certain that the same mix is always used under the same conditions. To return to our following our part, after the manufacturing outline is completed and approved it is issued to the appropriate production departments where the part will be manufactured. Experienced leadmen and workers are normally capable of working from the manufacturing outline without referring to the process specifications for details of the procedure. The specifications are useful, however, for reference in cases of doubt and for training of new and less-experienced personnel. They are also useful when new procedures are specified and when standard procedures are revised.

The "police department" at Zenith which assures that the part will be manufactured according to blueprint and under approved processes is the Inspection or Quality Control Department. To this department the process specifications are of real value. In the absence of specifications, the task of inspecting for process and quality control is so arbitrary as to become completely unwieldy. Primarily at the request of the Inspection Department, Zenith Engineering has prepared a comprehensive manual on acceptance limits and rework procedures. This manual, The Acceptance and Rework Manual, defines in detail the nature and magnitude of defects and discrepancies which are: (1) acceptable without rework; (2) reworkable; and, (3) non-reworkable. In addition, standard procedures for all types of rework are established. The manual has been approved for use by Wright Field, but a great deal of work remains to be done to resolve the many questions arising from the large scope covered. The manual's significance lies in its being an approach toward the desired end of eliminating the primitive guesswork procedures from quality control inspection of fiberglass laminate and sandwich radomes.

Summarizing the progress of our hypothetical job, the process specification was used in varying degrees at each stage of its manufacture. Its most important role was played in Planning, Manufacturing, and Quality Control, and to lesser degrees elsewhere. At Zenith, the policy of basing specifications on engineering principles has gradually emerged. Zenith specifications are prepared to reflect procedures which have been proved to provide sound structural parts. It is in the collection and analysis of test data which are used as a basis for procedure specifications that the integration of the Engineering Department into the specification picture is accomplished.

Development of Process Data:

Radomes have been manufactured by Zenith for several years and certain basic processes used in normal[1] applications have evolved. Since the industry is a relatively young one, many of the engineering requirements currently in use are based upon test results obtained from the early radomes. For this reason, process data for the manufacture of the normal application radomes is now largely restricted to those problems which arise in production. These manu-

(1) In the context of this paper, "normal" radomes are considered as those which are to be used on subsonic aircraft.

facturing problems arise from time to time and usually involve short range investigations for immediate solutions. Typical of this is the problem which arose recently involving the need for a solvent to remove a residue from the flutes of a "lost-wax" construction. A program was set up to determine: first, which solvent or solvents would remove the residue; and second, what effects, if any, the selected solvents will have on the physical properties of fiberglass laminates. The data obtained indicated no deleterious effect, so process specifications were written stating: first, which solvent to use; second, what minimum temperature would provide the desired rapid dissolving of the residue; and third, the maximum exposure time which could be safely allowed.

Standard processes for the manufacture of radomes for supersonic aircraft and missiles have necessarily lagged somewhat behind the demand for these radomes. Since specifications for these radomes are needed probably even more than those for the more standard types, it is necessary to translate research data into process information almost as fast as it is produced. Research and development in this category must be designed to provide process data as well as design strength data. In many of these cases, speed is essential, and as soon as parts can consistently be fabricated to meet the required properties production commences. Obviously, the process used in the first attainment of the target is not always the best approach. For this reason process development often continues even when production radomes are coming off the line. While the process development continues, the writer of the process specification can contribute toward the ultimate usefulness of the information being obtained. Since, as was pointed out in the beginning, the radomes must be manufactured according to military specifications, it is important that the research being conducted be pointed toward the following. First, is the process being evolved in strict compliance with the military specifications? If not, what modifications are required to bring the process into compliance? Second, since at Zenith we are striving for generalized, large-scope specifications, how is the information to be formulated to provide this general coverage? To accomplish this second point, it is necessary to anticipate production problems which may be encountered should the process be adopted. By directing research along the above lines, a great deal of unnecessary and misdirected work may be avoided, and the net result should be a reliable process which will be acceptable to the Military.

Flexibility of Specifications:

The final significant feature of process specifications which we will discuss is their flexibility which will provide accuracy in reflecting trends in manufacturing practice and in materials. We have emphasized the importance of specifications in their ability to standardize production techniques and thereby lend themselves to the maintenance of quality. This function notwithstanding, the specifications would be targets of serious and valid criticism by production if they were allowed to become outmoded and obsolescent. It is vitally important, therefore, to provide "earphones" which can detect problems as they manifest themselves. At Zenith this flow of information has in the past come directly or indirectly from the Manufacturing Department, and corrective action has been taken accordingly. While this source is valuable and will remain in force, a hitherto untapped source is now being established.

The Inspection Department has undertaken to maintain a log of fabrication discrepancies referenced to the stage of the manufacturing process at which they occur. As the log is compiled it will provide a ready indication of repetitive trouble spots. When such trouble spots are detected the Materials and Process Group will be apprised of that fact and appropriate corrective action and revision of the specification accomplished, if the process is found to be the source. It is action of this sort which perhaps is the best insurance of the success of specifications. If the production people are convinced that the specifications are able to serve a useful purpose and that those responsible for the specifications are willing and able to aid in solving problems which arise, they are far less likely to regard the specifications as part of that scourge to production -- "paperwork." Once Production discovers that specifications need not hinder the work of moving radomes along the line, it will fully cooperate in their execution; and this, of course, is the ultimate aim of specifications -- to insure that parts emerging from the production line are indeed all they were originally engineered to be.

EXHIBIT A

INDEX TO ZENITH PROCESS SPECIFICATION MANUAL

Section VII - Preforming (600-699)

#600 - Technique of Preform Collection
#601 - Molding of Preform and Mat Laminates

Section VIII - Layup Procedures (700-799)

#700 - Layup Procedures for Void-Free Glass Fabric Laminates
#701 - Layup Procedures for Void-Free Glass Fabric Outside Skins for Sandwich Structures
#702 - Layup Procedures for Void-Free Glass Fabric Inside Skins for Sandwich Structures
#703 - Layup Procedures for Non-Void-Free Glass Fabric Laminates
#706 - Fabrication of Alkyd-Isocyanate Foam Sandwich Structures (Single and Multiple Layups)
#710 - Fabrication of Single Sandwich Honeycomb Structures with Void Free Outside and Inside Skins
#711 - Fabrication of Single Sandwich Honeycomb Structures with Void Free Outside and Non-Void-Free Inside Skins
#712 - Fabrication of Single Sandwich Honeycomb Structures with Non-Void-Free Outside and Inside Skins
#713 - Fabrication of Multiple Sandwich Honeycomb Structures with Void-Free Outside and Inside Skins
#714 - Fabrication of Multiple Sandwich Honeycomb Structures with Void-Free Outside and Non-Void-Free Inside Skins
#715 - Fabrication of Multiple Sandwich Honeycomb Structures with Non-Void-Free Outside and Non-Void-Free Inside Skins
#716 - Fabrication of Single Sandwich Wrapped Wax Structures with Void-Free Outside and Inside Skins
#717 - Fabrication of Single Sandwich Wrapped Wax Structures with Void-Free Outside and Non-Void-Free Inside Skins
#718 - Fabrication of Single Sandwich Wrapped Wax Structures with Non-Void-Free Outside and Inside Skins
#719 - Fabrication of Multiple Sandwich Wrapped Wax Structures with Void-Free Outside and Inside Skins
#720 - Fabrication of Multiple Sandwich Wrapped Wax Structures with Void-Free Outside and Non-Void-Free Inside Skins
#721 - Fabrication of Multiple Sandwich Wrapped Wax Structures with Non-Void-Free Outside and Inside Skins

Section IX - Vacuum Bags (800-899)

#800 - Preparation of PVA and PVC Vacuum Bags
#801 - Installation of Vacuum Bag and Application of Pressure

Section X - Parting Agents (900-999)

#900 - Application of Parting Agents

Section XI - Curing (1000-1099)

#1000 - Techniques of Heat Lamp and Sun Lamp Curing
#1001 - Matched Die Press Molded Glass Fabric Laminates
#1002 - Techniques of Oven Curing

Section XII - Inspection and Repair (1100-1199)

#1100 - Acceptance and Rework Manual

Section XIII - Finished Part Fabrication (1200-1299)

#1200 - Riveting of Solid Glass Cloth Laminates
#1201 - Drilling of Solid Glass Cloth Laminates
#1202 - Drilling of Acrylic Plastic Parts
#1203 - Sawing of Laminates
#1204 - Grinding of Laminates
#1205 - Trimming of Laminates
#1206 - Routing of Laminates
#1207 - Milling of Laminates

Section XIV - Protective Coatings (1300-1399)

#1300 - Application of Zinc Chromate Primer
#1301 - Application of Rain Erosion Coating
#1302 - Application of Rain Erosion Anti-Static Coating
#1303 - Application of Lacquer and Enamel Surface Coatings
#1304 - Application of Rain Erosion Boot

Section XV - Storage and Handling of Plastic Parts (1400-1499)

#1400 - Packaging of Plastics Parts for Shipment
#1401 - Crate Fabrication

Section XVI - Quality Control of Raw Materials (1500-1599)

#1500 - Quality Control of Incoming Polyester Resins
#1501 - Quality Control of Incoming Glass Fabrics and Mats
#1502 - Quality Control of Incoming Adhesives
#1503 - Quality Control of Incoming Catalysts, Accelerators and Promoters
#1504 - Quality Control of Incoming Honeycomb
#1505 - Quality Control of Incoming Components for Foam
#1506 - Control of Resin Content of Machine-Impregnated Glass Fabric
#1507 - Quality Control of Incoming Preimpregnated Fiberglass Fabric

Section XVII - Storage of Raw Materials (1600-1699)

#1600 - Storage of Resins
#1601 - Storage of Glass Fabrics and Mats
#1602 - Storage of Foam Components
#1603 - Storage of Catalysts and Accelerators

EXHIBIT B

INTRODUCTION TO ZENITH PROCESS SPECIFICATION MANUAL

Purpose - It is the purpose of this Manual of Specifications to set forth the procedures and processes which are practiced in the production of reinforced plastics parts by Zenith.

Scope

This Manual of Specifications shall embrace all phases of production except those which are standard shop practice and of a nature so commonplace as to be not germane to a manual of this sort. The specifications included in this manual shall be acceptable to our customers, to the cognizant Government Agencies, or to both when both are concerned. Therefore, no specification shall be included in this manual until it has received written approval from the responsible authority. A copy of such written approval shall be attached to, and form a part of the specification.

This Manual of Specifications shall serve as a reference for all phases of planning for part production. As such, it shall be referenced in Engineering Drawings, Production Fabrication Outlines, and Process Bulletins and Specifications for specific parts. When the entire Manual of Specifications is to be referenced it shall be referenced as "1A-1000". When only one or a few sections are to be referenced the appropriate section numbers as listed in the Index shall be referenced.

Responsibility and Implementation

Responsibility - It shall be the duty of the Materials and Process Group to prepare all specifications. As part of this duty, that group shall be responsible for the compliance of all active Process Specifications to applicable Government and customer specifications and requirements. The Materials and Process Group shall conduct laboratory test programs for the purpose of obtaining information necessary to the preparation of specifications.

Implementation - It shall be the duty of Inspection Department to be thoroughly familiar with all Process Specifications and to insure Production compliance with the specifications. Difficulties in conforming to the Process Specifications shall be reported to Engineering Department which shall consider the problem for possible specification revision.

Form for Specifications - In general, the Process Specifications shall take the form to be described. In certain cases the nature of the subject will dictate the need for slightly modified forms.

Title - The title shall be listed.

Scope - The scope section shall specify precisely what the specification deals with, and coordinates with other specifications to place the subject in proper relation to the Process Manual as a whole.

Materials - This section shall specify all materials which are used in the particular process. Generally, very common materials which are normally used in the shop are not necessarily specified. In most cases a source of supply for the materials is listed.

Equipment - The equipment section shall call out equipment, tools, etc. which are peculiar to the operations with which the specification is concerned. Standard shop equipment will not necessarily be mentioned.

Procedures - Detailed descriptions of the various procedures of the process shall be specified in this section. All variations in the procedure which may be required to conform to the variations between customer requirements shall be included.

Process Control - This section specifies measures which must be taken to insure proper functioning of the process. In most cases this will consist of a list of those operations in the process which are of a critical nature and which, if improperly performed, can adversely affect the part and/or process.