DRAWING CONTROL PROCEDURE

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The topic of this presentation is the procurement of engineering drawings, and the control of the quality of these drawings. Although I am directly concerned with drawings, I feel it is only natural to be more interested in an item itself than in the drawing of the item. This is particularly true of engineering drawings of an item. With the item itself, there is no necessity to try to visualize anything. It is right there. Depending on its size and complexity, you can turn it over in your fingers, or walk around it. You can study it, analyze it. There is little misunderstanding or misinterpretation. However, with an engineering drawing, it is necessary to be able to visualize what the item is really like. Depending on the scale of the drawing, you might have to picture it much larger, or much smaller. In other words, it requires more thought to visualize what an object is really like when only the engineering drawing is available.

When it comes to engineering drawings of a training device, the same holds true. Some devices are very large, and cannot be drawn on a single sheet. It might take several sheets, showing different sections and views. This requires more thought and interpretation. However, engineering drawings are a necessity. We cannot progress without them. And, since they are a necessity, they must perform their intended function. They must convey the correct information as clearly as possible. They must tell a story, an accurate story, without misleading the user, with a minimum of interpretation. They must transmit the same information to whomever should be required to read the drawing, be it a machinist, an inspector, or an engineer.

Adequate time must be taken in their preparation to insure this. Upon their completion, adequate time must be taken to check them. Sometimes, when a device is in the prototype stage, be it fabrication or assembly of parts, troubles are encountered due to errors on the drawings. These errors might include incorrect or missing dimensions, inadequate clearances between mating parts, failure to allow for adequate travel of moving parts, or improper materials or finishes. These errors often are the result of inadequate time allowed for the drawing preparation and checking. At times, when the troubles are coupled with a tight delivery date for the device, the errors are corrected on the spot, with all good intentions of correcting the drawings as soon as possible. Unfortunately, too often the drawings are never corrected. Sometime later, if the device should be fabricated in production quantities, the cost of these errors is multiplied. This results in needless cost to the Government. What we are attempting to do here is to eliminate this condition. With the proper care and control maintained at the proper time, it can be eliminated.

This brings us to the primary purpose of acquiring drawings. The purpose is twofold: First, so that we may be able to economically procure additional quantities of devices in the future, and second, so as to be able to maintain the devices in the field. In addition, drawings are sometimes procured merely for reference purposes.

Before the drawings can actually be procured, a sequence of events must first take place. The first of these occurs in the writing of the contract requirements. At this point, a decision is made concerning the future procurement possibilities of the device under consideration. The result of this decision will directly govern the scope of the drawing procurement. If it is very unlikely there will be any reprocurement, complete fabrication drawings are not ordered. Complete fabrication drawings are expensive, and it is a waste of money to procure them if they are not needed. However, if there is a reasonable likelihood there will be a reprocurement order, fabrication drawings are ordered. In every case, maximum use of existing data should be made. New drawings should never be made if existing drawings will suffice.

So you can see, the decision for the procurement or non-procurement of drawings is governed directly by their anticipated usage at some future date.

Once the decision has been made that drawings are required, the appropriate categories and forms of drawings are selected. These categories and forms are defined in MIL-D-1000, and are based on the intended use of the drawings. When you as a contractor are making your cost estimate for drawings, you should base it solely on what forms and categories of drawings are requested. In the process of doing this, you should bear in mind that one or more drawings made for one category may suffice for another. You should not make two drawings of the same item simply because the drawing falls into two categories. One drawing will suffice. Regardless of what forms and categories are required, the drawings must depict the device for which they were drawn, and must serve their intended purpose. This is the only way we can be assured of the elimination of needless delays and cost when the drawings are put to their intended use. This is particularly so in the case of quantity procurement, when the costs due to drawing errors are multiplied. The only way we can economically procure more of the same devices in the future is to eliminate this condition.

The final decision is that of the appropriate drawing media required. This may be originals, full size reproducibles, microfilm, or prints, or some combination thereof. Again, the intended use of the drawings governs this selection.

While we are discussing categories of drawings, I would like to take a little time to try to clarify a condition which exists with respect to MIL-D-1000. In this specification, procurement drawings are listed under two categories, "E" and "F". This has resulted in duplication of ordering. I would like to clarify this situation so as to eliminate this duplication.

Category E drawings consist of procurement drawings of identical items. Drawings in this category are made in order to permit future fabrication of additional identical items from the original or other sources, without additional design effort, or recourse to the original design activity. These drawings must provide all the necessary design, engineering, manufacturing, and quality support information to enable the Government to procure as I have just described.

Category F drawings consist of procurement drawings of interchangeable items. Drawings in this category are made in order to permit future fabrication of the same items from the original source, or functionally and physically interchangeable items from other sources.

Confusion arises in the difference between Category E, identical items, and Category F, interchangeable items. The basic difference is this: If two items are identical, they are obviously interchangeable; However, two items can be interchangeable without being identical. To be sure of being able to procure an identical item in the future, Category E is ordered. On the other hand, if another item, functionally and physically interchangeable, will suffice, Category F is ordered. Fewer drawings are required under Category F than under Category E, since Category E includes all the data supplied in Category F plus additional detailed information. The important thing to remember here is that both Category E and F should never be ordered for the same device.

As I previously mentioned, the Navy requires that all drawings be made in accordance with MIL-D-1000. Along with this, MIL-D-5480 is used to specify the type of reproductions required, and MIL-M-9868 to cover microfilming. Since all of these specifications leave it up to the procuring agency to decide specifically what type of drawing and drawing media are required in a given case, the Center has issued its own document, referencing these specifications, and stating specifically in what medium the data should be supplied. This document is called NTDC Bulletin 33-1, Preparation of Engineering Drawings, Lists, Associated Data, Microreproduction of Engineering Data and Preparation of Aperture and Tabulation Cards.

This Bulletin is part of all contracts in which drawings are requested.

Once the drawing requirements have been established, the next step is to implement procedures which will insure that these requirements are being met. This is done by use of an acceptable drawing control procedure. As a minimum, this procedure must show the following:

a. The process by which it is assured all parts are made from the current revisions.

b. The process by which feedback from the shop assures the latest information is fed back to the drawings, with a specified time interval for feedback.

c. The process by which the latest information is incorporated in the drawings, and the time interval required.

Up to now we have been primarily concerned with the acquisition of drawings. I would now like to spend some time discussing the control of their quality.

First of all, just what do we mean by the quality of an engineering drawing? The answer to this question can vary considerably, depending upon the viewpoint of the person asking the question. Let us consider a few.

First, from strictly the draftsman's point of view, the drawing might be high quality. The lines might be sharp; the scale might be adequate; the views might be adequate. However, there might be many dimensional errors, so that the part, when fabricated, will not perform its intended function. Thus, the drawing is actually of poor quality.

Second, let us consider the reproduction point of view. The drawing may be similar to the example I just gave, but in this case the dimensions are correct. However, the drawing may be made on very poor quality paper which does not give a good reproduction. Thus, again it is a poor quality drawing.

Next let us consider the viewpoint of the machinist who must use the drawing to fabricate the part. The lines might be sharp; the scale might be adequate; the views might be adequate; the dimensions are all correct; and the original paper is such that the reproduction is sharp and clear. However, even though the dimensions are correct, they are located haphazardly on the drawing. Dimensions that are closely interdependent are widely scattered, so that the machinist has to continually go from one view or one sheet to another to find related dimensions. The same applies to the inspector. This *results in a lot of wasted time, and time is money. Thus, again a poor quality drawing.*

So you can see that before a drawing can really be considered good quality it must pass several tests. It must have good reproducibility; it must be neat; it must be drawn to an adequate scale; it must have adequate views; it must have complete, correct and properly located dimensions; and, most important of all, the part it depicts must perform its intended function. When any of these requirements is lacking, the drawing is not serving its intended purpose. Actually, a drawing is a tool. It is the tool by which parts are fabricated and products are assembled. You cannot do a good job with poor quality tools. The same applies to drawings.

It is essential that effective quality assurance measures be taken to assure that the drawings procured by the Center permit a good job to be done; that they do not compromise the quality requirements as governed by their intended use. These quality assurance measures begin with you as the contractor. Before your Engineering Department undertakes the task of designing the device, your Project Engineer must have a clear understanding of the drawing requirements. It is his responsibility to see to it that these requirements are met. All of his efforts must be channeled in the direction of supplying high quality drawings in the required forms and categories, in the required

format, and in the required drawing media. If any questions should arise along these lines, they whould be resolved before the task is undertaken.

When drawings are complete and ready for checking, the checker should be given a copy of the contract requirement. His first step in checking the drawings should be to insure the drawings meet these requirements. This includes the proper categories and forms, and the proper drawing media. Once this has been done, he should cross-check the drawing lists against the drawings proper. Finally, he should check such things as title block information, revision status, function of parts, tolerances of parts for proper mating, materials, etc. Not until all these items have been verified should a set of drawings be prepared for delivery to the Center.

Upon receipt of drawings at the Center, they are further checked before acceptance. After acceptance, they are put in the drawing file. This basically completes the chain of events from the writing of the drawing requirements to the fulfillment of these requirements.

At this point the drawings are now available for general use. They have met all the contract requirements, and depict the device for which they were drawn to the degree for which they were intended.

This leads us up to the next phase of our discussion, namely drawing revision control. No matter what the use may be, it is of the utmost importance that the drawings in the file be constantly kept up to date. The drawings do not serve their intended purpose if they are not kept current with the device in the field. This can only be done by the careful control of revisions. For this reason it is imperative that modifications to a training device are not made without an accompanying revision to the master drawing in the file. It must be remembered that only the drawing in the Center file is the master drawing. This is true regardless of the medium of the drawing, be it original, full size reproducible, or microfilm. This is also true irrespective of what a contractor may have in his file. If there is any discrepancy between the drawing in the Center file and any other, the file drawing shall take precedence. For this reason it is mandatory that the master drawing be kept up to date. Thus, whenever revisions are to be made to drawings, the master drawings in the Center file shall be the ones revised. Until this is done, the change cannot be considered complete. Revisions to any other copies shall not be valid. As an example, a contractor may have working drawings for his daily use, but whenever they are modified, the master drawing in the file must be modified accordingly.

Tied closely with this revision control is a good drawing filing and retrieval system. This system must avoid any possibility of duplication of filing. There cannot be more than one reproducible copy of the same drawing in the master file. If this is not adhered to, it can result in two or more master drawings bearing the same number, but containing different revisions and different data. This must never happen. Thus, when your Engineering Department makes a revision to a drawing, they must be very careful as to how the revision affects the existing data already on the master drawing.

From what I have presented to you, I think you can see clearly the various steps necessary before we reach a point where we have an acceptable set of drawings in the file. Acceptable means they meet all the contract requirements, and in particular are accurate and up-to-date. It cannot be overstressed that we must have accurate drawings. In some cases it is better to have no drawings at all than to have on file drawings bearing several mistakes. At least if we don't have the drawing we can't spend the money to make a part that is wrong. Inaccurate drawings are very costly to the Government. Often the mistakes are not found until the parts have been fabricated, or are in process, and in many cases the parts must be scrapped and new ones made. In addition, it costs money to have the drawings corrected.

We can sum up this entire presentation by stating that high quality drawings are the result of a team effort. Everyone involved in the procurement, production, quality assurance and revision of engineering drawings must constantly aim at producing and maintaining high quality drawings for the Center. We must all keep in mind the basic reasons why we require the drawings: To permit us to procure and maintain training devices at a minimum cost to the Government.

MAINTAINABILITY, MAINTENANCE ENGINEERING ANALYSIS RECORDS AND CONTRACTOR AUGMENTED SUPPORT AS A PART OF THE INTEGRATED LOGISTICS SUPPORT SYSTEM

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The effectiveness of a training device is a measure of "how well" the device performs its mission, "how long" the device will maintain a specified level of performance throughout a given mission, and "how often" the device is ready when it is needed. The Department of Defense has stated by the issuance of Department of Defense Directive 4100.35, that material readiness, or "how often" and equipment is available, can best be achieved through effective integrated logistic support.

With the increasing amount of money required to support the training devices in the field and realizing the relatively poor availability of them in the past, the Naval Training Device Center recognized the need for more definitive, cost effective, logistic support requirements, and in June of 1966 the Center issued Bulletin 40-1 entitled "Integrated Logistic Support for Training Devices." Bulletin 40-1 contains all of the contractual requirements necessary to provide for effective support of training devices for their programmed life cycle.

The elements comprising the Center's integrated logistic support requirements, and each element shown represents a separate section of Bulletin 40-1. The sections and titles of Bulletin 40-1 are as follows:

Section 1 - Maintainability of Training Devices
Section 2 - Preparation of Maintenance Engineering Analysis Records for Training Devices
Section 3 - Site Preparation and Contractor Augmented Support
Section 4 - Contractor Conducted Training
Section 5 - Provisioning Technical Documentation and Repair Parts
Section 6 - Technical Publications

Bulletin 40-1 requires that the contractor establish a program to implement the requirements of each section, in entirety or in part, as determined by the dollar value, criticality, complexity, original design, or number of units of the particular procurement. The requirements of Bulletin 40-1 constitute the total support requirements necessary to assure the effective support of training devices by the Government at the earliest point in time. The Maintenance Engineering Analysis Records, required by Section 2, will be one of the primary instruments for the contractor to insure the coordination of his support groups. I will discuss the requirements of Section 2 a little later.

Bulletin 40-1 requires a maximum of four support control stages during the life of the contract: