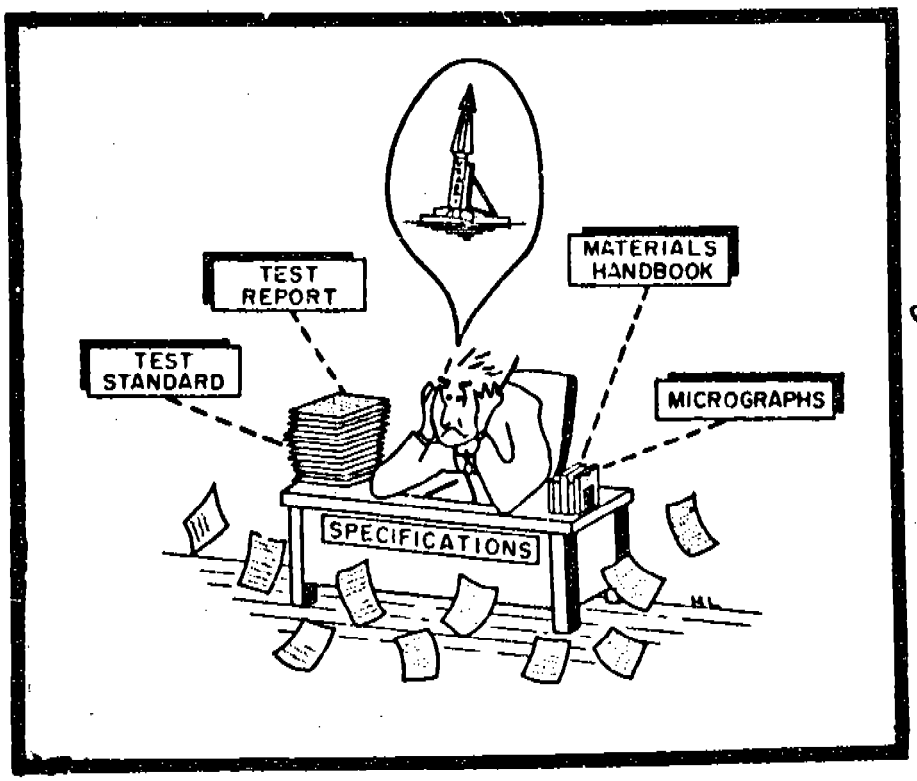
WATERTOWN ARSENAL LABORATORIES

Monograph Series

NUMBER 30

PHILOSOPHY AND PREPARATION OF
ORDNANCE MATERIALS SPECIFICATIONS



by

KENNETH H. ABBOTT

MAY 1961

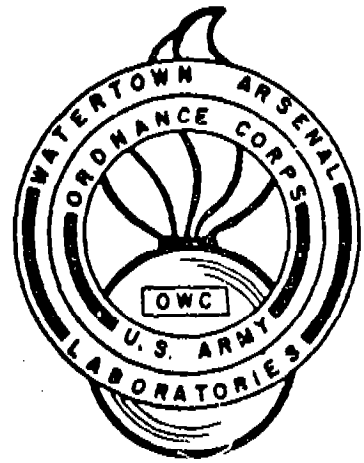
PHILOSOPHY AND PREPARATION OF ORDNANCE MATERIALS SPECIFICATIONS

Presented by

KENNETH H. ABBOTT

at

AOA Castings Section Meeting
held at OTAC on 9-10 March 1961



MAY 1961

PHILOSOPHY AND PREPARATION OF ORDNANCE MATERIALS SPECIFICATIONS

Each item of military hardware is manufactured to and accepted in accordance with a specification for that particular item. This specification, called an end item specification, contains requirements which must be met so that the item will function in service. Various dimensions, standards of quality, and acceptance tests are generally included in the specificatior In addition, other military specifications and standards are made a part of the end item specification by stipulation of their applicability. One of these documents is the Materials Specifications.

The Materials Specification covers a specific class of materials in a generic manner with respect to end items use of the entire class, but is detailed for parts of the class. For example, the specification which covers certain heat treatable steels recognizes that they may be employed in an end item at any one of a variety of strength levels. Hence, specification requirements for probable strength ranges are contained in the specification. Thus, regardless of the strength demanded by the end-item use, the materials specification is applicable. In addition to strength, several standards of cleanliness and toughness may be included such that a combination of properties, any set of which may be demanded for an end item use, will be covered in the materials specification.

At the same time, it is recognized that certain unusual property combinations may be required at times, over and above those specified in the materials specification, and allowance is made for these to be specified by the procuring agency in the end item specification. Because of the general usefulness of the materials specifications, let us look at the general philosophy that guides Army Ordnance in the preparation of these documents.

The guiding philosophy of a materials specification can best be described by noting the particular philosophy employed for each part of the specification. Figure 1 has been prepared to describe these various specification parts. The first part or scope of the specification is an accurate description of the class of materials covered. It is frequently subdivided into two or more grades when such grades or sub-classes are employed frequently in certain kinds of end items. In general, the scope reflects the many kinds of uses to which the materials will be applied, and the number of grades specified is purely for the convenience of those who prepare end item specifications. The second part merely defines specifications, standards, and other documents which are an integral part of the materials specification. Obviously, this is done to minimize the size of the specification and to minimize labor and paper required for specification preparation.

MATERIALS SPECIFICATION

1. SCOPE _____ WHAT IT INCLUDES
2. REFERENCES _____ OTHER APPLICABLE SPECIFICATIONS
3. REQUIREMENTS _____ WHAT IS NEEDED
4. QUALITY ASSURANCE PROVISIONS _____ PROOF THAT IT IS OBTAINED
5. PACKAGING _____ HOW IT IS PREPARED FOR SHIPMENT
6. NOTES _____ OTHER RELATED ITEMS

FIGURE 1

The third and fourth parts are the heart of the specification. Part three defines the actual metallurgical and mechanical properties which are required. The philosophy here is that only those properties which are essential for adequate service performance of the material should be specified. Many applied research programs on material in Ordnance are devoted to studying the minimum property requirements which are needed. The results of these studies are applied in parts three and four of materials specifications. Part four defines the tests which must be performed to insure that requirements of part three are met.

We always strive for simple, standard tests *which can be performed in the materials manufacturer's plant.* This is extremely important since we sincerely believe that the manufacturer has the right to know whether his material is acceptable before he ships it to the fabricator. If it isn't, he can re-heat treat or otherwise modify his practice to avoid unnecessary delays caused by rejection at the fabricator's plant. Obviously, this is also in the best interest of the government. Part five defines the preparation and packaging (if applicable) which are required prior to shipment to the fabricator. Part six covers a variety of information which is not required in the specification, but which is of value to the manufacturer in his operation and use of the specification.

The general procedure for the evolution of a materials specification may be of interest. First, Ordnance must determine the exact metallurgical and mechanical properties which are demanded in the materials to insure end item reliability. Other related items such as weldability or general fabricability are also considered for obvious reasons. For special materials, even melting practice and other metal processing operations may be of concern.

From these considerations, a draft of the specification is prepared. This draft is sent to various Ordnance Agencies for study and constructive comment. The draft and the comments are reviewed to establish a coordinated Ordnance position. As you may expect, meetings are frequently required to resolve minor differences.

Once the Ordnance position is established, the revised draft is distributed to technical representatives of the metal industry which are closely associated with the class of materials covered. A meeting is then called to resolve differences between industry and Ordnance viewpoints. However, the metallurgical and mechanical properties demanded for end-item use cannot be compromised. Any other compromise which does not dilute the necessary reliability is made. The revised draft is then coordinated with the Army, Navy, and Air Force to become an accepted MIL specification.

As an example of how the process works, specification MIL-A-11356B which covers cast steel armor will be discussed briefly. Research and development work in Ordnance has evolved the metallurgical and mechanical properties demanded for adequate ballistic protection. Because of the strategic nature of certain alloy elements in time of war, the amounts of alloying elements are generally recommended to be held to the minimum required, and ballistic data has justified using fairly lean alloys. Based on this data the specification was prepared, coordinated in Ordnance and with industry, and standardized.

As indicated in Figure 2, the chemical composition is left to the discretion of the producer. By means of a pre-production qualification test, the producer demonstrates that the composition he selects can meet all metallurgical, mechanical, and ballistic requirements. Once this is accomplished, the allowable variation permitted in his chemical composition is as specified in Figure 2. Thus the government is assured that he does not deviate significantly from his chemistry, and the producer is allowed sufficient variation such that it can be maintained without undue hardship. The maximum limits specified are on carbon (for weldability) and on phosphorus and sulphur (for cleanliness).

MAXIMUM RANGES AND LIMITS FOR CHEMICAL COMPOSITION (LADLE OR CHECK ANALYSIS)

Element	Maximum Range	Maximum Limit
Carbon	0.10	0.35
Manganese: Up to 1.00%[1] incl.	0.30	-
Over 1.00%	0.50	-
Phosphorous	-	0.05
Sulphur	-	0.05
Silicon	0.50	-
Nickel	0.70	-
Chromium: Up to 1.50%[1] incl.	0.50	-
Over 1.50%	0.70	-
Molybdenum	0.20	-
Vanadium	0.10	-
Copper	0.50	-
Aluminum	-	- 2
Boron	-	- 2
Titanium	-	- 2
Calcium	-	- 2

FIGURE 2

Since the amount of alloy is generally minimized, the strength requirements decrease with increasg thickness to permit approximation to through hardening in all thicknesses specified. Strength is easured by means of a hardness test due to the linear relation between strength and hardness in artensitic steels. The adequacy of these required strengths shown in Figure 3 for end item use has ien demonstrated in Ordnance. Notice that the hardness test is a very simple one which can readily performed in the producer's plant.

BRINELL HARDNESS REQUIREMENTS (3000-Kg load)

Casting Thickness Specified - Inches	Armor Class	Brinell Hardness Range	Brinell Diameter Range - Millimeters	Rockwell C Hardness Range
1/4 to 1-1/4 incl.	1	302-341	3.50-3.30	32 - 35.5
1/4 to 1-1/4 incl.	2	241-293	3.90-3.55	22 - 30
Over 1-1/4 to 2-1/4 incl.	1 & 2	241-293	3.90-3.55	22 - 30
Over 2-1/4 to 3-3/4 incl.	1 & 2	229-269	4.00-3.70	19.5 - 27
Over 3-3/4 to 7 incl.	1 & 2	217-262	4.10-3.75	16.5 25.5
Over 7 to 12 incl.	1 & 2	201-241	4.25-3.90	13 - 22

FIGURE 3

A third essential feature in cast armor is the existence of adequate toughness at low ambient mperature (-40 to -65 F). This is assured by means of V-Notch Charpy impact tests which are also nducted in the producer's plant. The required test results are related to strength and specified in gure 4. The specimens are removed one inch below the armor surface and are positioned such that

the producer must have predominantly a tempered martensitic microstructure at this location in order to meet specification requirement.

MINIMUM V-NOTCH CHARPY IMPACT RESISTANCE REQUIREMENTS
IN FT. LBS AT -40 DEGREES F. ± 2 DEGREES F.

Brinell Hardness Numbers (see 4.7.2.2.2.2)	Rockwell C Hardness Numbers	Minimum Impact Resistance (Average of Two or More Tests)
Inclusive	Inclusive	Foot Pounds
191 - 200	- -	48
201 - 212	13.0 - 15.0	43
213 - 229	15.1 - 19.5	38
230 - 248	19.6 - 23.4	33
249 - 269	23.5 - 26.8	28
270 - 277	26.9 - 27.9	26
278 - 285	28.0 - 29.0	24
286 - 302	29.1 - 31.1	21
303 - 311	31.2 - 32.2	18
312 - 321	32.3 - 33.3	15
322 - 331	33.4 - 34.4	13
332 - 341	34.5 - 35.4	11
342 - 352	35.5 - 36.6	10

FIGURE 4

The last essential item is soundness. This is accomplished through the control of inclusion forming elements in the composition, and by radiography of castings in the qualification test and by random inspection during production.

It is important to note in summary that the three essential specification requirements, strength, toughness, and soundness are all evaluated in the material producer's plant so that he can correct immediately any deficiencies in his practice when they occur. Shipment of rejectable material is also minimized. This specification, MIL-A-11356B has been fully coordinated in Ordnance and with industry and is reviewed and revised from time to time as the need arises. Hence, it is rather unique among specifications for materials which are subjected to severe loading conditions in service performance. It is also unique in that it exemplifies the intent of the Ordnance specification philosophy.

No doubt you are all curious, in view of General Ghormley's comments, as to the status of a materials specifications for pearlitic malleable iron. Let me say only that a draft of such a specification has been prepared and is currently being coordinated in Ordnance. When a coordinated Ordnance position has been established, copies of the revised draft will be distributed to the technical members of this committee for review and comment. I know that we in Ordnance can rely on you representatives of industry to help us in making the specification one that will fulfill our expectations of just what the specification should be.