THE CHOICE OF ALLOYS FOR WATER WORK DESIGN.*

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IN the design of waterworks equipment, the engineer makes use of the various non-corrosive metallic alloys only to such extent as the inaccessibility of the equipment or the danger of interruption of service render it imperative to use some material other than iron or steel. Consequently, the amount of such material has, in the past, been slight in comparison with the magnitude of other materials entering into such work, and the engineer has been content to accept, largely without question, such alloys as were commercially available, without any extensive study of the applicability of any particular alloy to the purpose for which it was to be used.

The increasing magnitude of such work, however, makes the proper selection of alloys of increasing importance to the engineer, and it is the purpose of this paper, not to attempt to set forth in detail any fixed rules to govern selection, but to open the way for discussion and to bring forth the results of the study of others who have been able to make a more detailed study of the matter than has the writer.

Alloys are used for waterworks construction in two forms:—

1. *Castings.* In this form they appear in parts the shape or purpose of which is such that it is possible for the material to pass directly from the foundry to the point of application, with only such intervening fabrication as tends in no way to alter the structure of the material, or to change its physical characteristics.

2. *Bars or tubes.* In this form these alloys must, in nearly all cases, be so fabricated after leaving the foundry that their structure and physical characteristics are materially changed. This fabrication consists of forging, rolling, extruding or drawing.

The ideal alloy must possess three characteristics which, in the order of their relative importance, may be classed as follows:—

1. The material must be able to withstand, for an indefinite period, the disintegrating action of the elements with which it is to come in contact, this action taking the form of corrosion, errosion or electrolysis, either or all of which may be present.

2. The material must be of such structure that it will successfully withstand disintegration due to the failure of its component parts to retain their original relation one to another, and must be free from internal stress which will produce progressive failure entirely independent of any exterior agency. This latter requirement implies a composition capable of successful fabrication under existing commercial conditions.

3. Since the materials are comparatively costly, it is desirable that the physical characteristics be as high as practicable in order that the desired result may be obtained at the least expense.

It is desirable to bring to your attention four of the classes of alloys, and to consider briefly their ability to fulfill the requirements of the above specifications, as follows:—

The bronzes, or copper-tin alloys.
The brasses, or copper-zinc alloys.
The copper-nickel alloys, and
The nickel-steel alloys.

The bronzes are of ancient origin and, in slightly varying composition, have been used for many centuries. The most commonly accepted composition to-day appears to be that of the so-called "naval bronze," consisting of 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc.

Castings of this alloy fulfill the requirements of the foregoing specifications in a very satisfactory manner. They are non-corrosive in the presence of nearly, if not all, the elements with which they are ordinarily brought in contact, they are easily obtainable, of a homogeneous character under ordinary commercial conditions, are stable and constant in physical characteristics, and the material is one that works well in the ordinary machinery operations.

Their physical characteristics are sufficiently high so that apparatus does not need to be unwieldy or unduly heavy in design to obtain the requisite strength under any ordinary conditions. A tensile strength of 30,000 pounds per square inch, a yield point of 15,000 pounds and an elongation of 15 per cent. in two inches can easily be obtained.

Rigid adherence to the composition as given above does not appear essential. The copper may be reduced to 85 per cent., with a corresponding increase in the zinc content, or with a corresponding addition of lead without materially changing the ability of the resulting casting to resist corrosion and without material change in its physical characteristics. In fact, in the presence of sulphur the addition of lead appears to aid the resistance to corrosion.

Where the material is to be used as a bearing metal, as in the seats of large gates, a considerable variation in the composition is desirable. The United States Reclamation Service has worked out for this purpose two alloys to be used in opposition to one another, as follows:—

82.8 per cent. copper, 4.8 per cent. tin, 4.4 per cent. zinc, and 8 per cent. lead.

82.7 per cent. copper, 7.1 per cent. tin, 5.3 per cent. zinc, and 4.9 per cent. lead.

Experiments by the writer, while indicating the impracticability of attempting to confine the composition as closely as indicated, demonstrate that alloys of this nature containing about 5 per cent. lead in one and 8 per cent. in the other, with corresponding differences in the tin content, were very satisfactory for the purpose.

Alloys of the above nature may be used for castings only, as their high tin content makes it impossible to hammer, forge, roll or draw them successfully, so that, where rods or tubes are required, the content of tin must not exceed 2 per cent., and most manufacturers hold to a maximum of 1½ per cent.

Where conditions of design require greater physical characteristics than shown by the bronzes, or where forged, rolled or drawn forms are required, the engineer commonly resorts to the brasses, of which there are an endless variety, many of them of little value, but of which a number have proven highly satisfactory.

For castings of this character, manganese bronze has been very generally accepted and has given very satisfactory service. A characteristic casting of this material shows a composition of about 56 per cent. copper, 40 per cent. zinc, 1 per cent. tin, 1.27 per cent. iron, and 1.8 per cent. manganese. It will be noted that the manganese content is small, and it does not appear essential that the analysis of the completed casting show any such content,

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