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NAVY DOCUMENT CONVERSION PROGRAM

PROJECT: PIPE FLANGES

INTERIM REPORT

Prepared by George G. Sharp, Inc.
May 2, 1990

Navy Document Conversion Program

Project: Pipe Flanges

1. Objective. The prescribed objective of this project is:

> *To develop an overall strategy and a specific plan of action for the commercialization of Navy pipe flange patterns to be used in conjunction with on-going commercialization projects for pumps, valves, strainers, and other flanged piping components.*[1]

This objective is derived from an understanding of the problem reflected in the SP6 Project abstract, which states as follows:

> *There currently exists in the U.S. Marine industry, two systems of pipe flanges - so called Navy flanges (Mil-Spec) and commercial (ANSI). Both flange systems have general attributes (pipe sizes, pressure ratings, material availability) that are identical to each other. The major difference between them is in their physical dimensions (diameter, thickness, bolt holes) which makes them incompatible with each other.*
>
> *The construction of most Navy ships results in a combination of Navy and commercial flanges being installed, many times in the same piping system. This creates confusion for the designer, procurer, and installer. Ultimately, the confusion is carried over to the ship's operations and logistics in that two flange systems must be provisioned. Also pumps, valves, and other components with otherwise similar attributes are made unique due to their flange types, further complicating the ship's stores.*[1]

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[1]From SP6 Project Abstract

2. Approach. The starting point in this project was to determine the scope of the incompatibility caused by specifying a combination of Navy and commercial standards for flanges in Navy ship specifications. Two principal Navy Military Standards specify piping system flange requirements. These are MIL-STD-777E(SH) for Naval surface ships and MIL-STD-438E(SH) for submarines. These two standards form the primary basis for material and component selection for all piping systems and are invoked in Navy ship specifications for their respective categories of ships. Minor tailoring in the ship specification is usually done, but the two standards reflect a vast wealth of experience and lessons learned over the years for piping systems in both construction and operation of naval ships. It may seem unusual to include a submarine standard in a commercially oriented Navy document conversion task, but it is done because this submarine standard does, in fact, specify commercial steel and commercial flanges for all its steel piping system applications. If requirements peculiar to submarines become manifest, they will be segregated out for separate treatment as appropriate.

Following a determination of the incompatibilities, an analysis of the standardization efforts necessary to reduce or eliminate them will be made. This result will be looked at in the light of existing industry and Navy practices relating to the utilization of flanges. Following this, an action plan will be developed for achieving the desired objective.

3. The Basic Flange References. As mentioned above, the Navy's two principal documents for specifying materials and standards for use in piping systems are:

- MIL-STD-777E(SH) - Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships (7 February 1986)
- MIL-STD-438E(SHIPS) - Schedule of Piping, Valves, Fittings, and Associated Piping Components for Submarine Service (amended by Notice 1 of 8 November 1983)

Each of these documents categorizes systems by service and associated design pressures. The service categories listed in Appendix A to this report are those from MIL-STD-777, and those in Appendix B are from MIL-STD-438. Also listed in Appendixes A and B are the materials specified for flanges, and the applicable reference documents for those flanges. All of the documents (both drawings and specifications) cited in the two Military Standards for flange requirements are listed in summary below:

MIL-STD-777:

Drawings:

810-1385892 Flanges, Bronze, Special for Use with Butterfly Valves

810-1385915 Fittings, Pipe, Composition, Flanged, 100 psi Max. at 450°F Max. for All Services.

810-1385992 Flanges, CuNi, 250 psi[2], WOG[3], Welding Neck

810-4715319 NNSY Type Plan, Standard Flanges, CuNi Socket Welded

Specifications:

MIL-F-20042 Flange, Pipe & Bulkhead, Bronze (Silver Brazing)

MIL-F-20670 Flange, Pipe, Carbon Steel, 150 psi, WSP[4]

MIL-F-24227 Fittings and Flanges, Cast Bronze, Silver-brazing Suitable for Ultrasonic Inspection

* MIL-P-24608 Pipe, Fittings, & Adhesive Kits, Glass Reinforced Thermosetting Epoxy Resin for Shipboard Piping Systems

MS 18308 Alloy Steel Socket Welding Flanges and Flanged Nipples, 1/4 inch and 3/8 inch, 600 psi at 850 °F (maximum)

ANSI B 16.5 Pipe Flanges and Flanged Fittings

ANSI B 16.24 Bronze Pipe Flanges and Flange Fittings - Class 150 and 300

* Included because it is cited in MIL-STD-777, but MIL-P-24608 will not be further discussed in this report since glass reinforced plastic is considered

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[2] psi = lbf/in^2 = pounds force per square inch

[3] WOG = Water, oil, or gas

[4] WSP = Working steam pressure

outside the scope of this project. Noted, however, is the fact that the document specifies that face-to-face and center-to-face dimensions of flanged fittings are to be in accordance with the primary commercial specification for flanges, ANSI B16.5 (150 psi).

MIL-STD-438

Drawings:

803-1385861 Flanges, Sea Water, 700 psi Max

803-1385947 Flanges, Bronze, 700 psi, WOG for UT Inspection

810-1385992 Flanges, CuNi, 250 psi, WOG, Welding Neck

Specifications:

MIL-F-20042 Flange, Pipe & Bulkhead, Bronze (Silver Brazing)

ANSI B16.5 Pipe Flanges and Flanged Fittings

4. Review of the Basic Flange References for Incompatibilities. Examination of the information shown above and in Appendixes A and B reveals the following:

a. For steel, in every case, the referenced document for the specified material is a commercial (ASTM) specification, and the applicable standard for the flange is, with but two exceptions, the commercial specification, ANSI B16.5. The two exceptions are for services Y-2 and Y-3 (Service Y-2 is Overflows, sounding tubes, vents and air escapes for fuel tanks (except JP-5). Service Y-3 is Overflows, sounding tubes, vents and air escapes for other than fuel tanks, fresh water (except potable), clean ballast, voids, etc.). For services Y-2 and Y-3, MIL-F-20670 is specified for flanges. Services Y-2 and Y-3 require steel pipe and bronze valves in the same piping system. MIL-F-20670 provides for steel flanges to mate steel pipe to bronze valves. In doing so, MIL-F-20670 (steel) specifies flange dimensions that conform to those of MIL-F-20042 (bronze). This could be an example of what was described as part of the problem in the project abstract, i.e. mixing commercial and Mil Spec flange standards. However, it can be seen that this is not an inadvertent application. It results from a reasoned choice in mixing different materials in the same system.

b. For nonferrous materials, in contrast to the situation for steel, a wide variety of flange standards is seen to be in use. They are summarized below:

For MIL-STD-777:

Copper nickel:	Dwg 810-4715319, Dwg 810-1385892, Dwg 810-1385992, ANSI B16.5
Bronze:	MIL-F-20042, Dwg 810-1385892, Dwg 810-1385915 MIL-F-24227, ANSI B16.24
Nickel-copper alloy:	"Commercial", MS18308, ANSI B16.5

For MIL-STD-438:

Copper-nickel:	Dwg 810-1385992, ANSI B16.5 (Drilling and OD IAW MIL-F-20042)
Bronze:	MIL-F-20042, Dwg 810-1385947
Nickel-Copper alloy:	ANSI B16.5, Dwg 810-1385861

5. Preliminary Findings. From the foregoing, two preliminary findings emerge:

(1) **Insofar as flanges are concerned, a fundamental difference is found between steel applications and nonferrous applications. For steel, ANSI B16.5 is the principal dimensional standard; for nonferrous applications, MIL-F-20042 is the principal dimensional standard.**

(2) **While ANSI B16.5 is the nearly unanimous choice for steel flanges, a variety of standards besides MIL-F-20042 are specified for nonferrous flanges.**

These preliminary findings will now be examined further by analyzing first, dimensional incompatibility between ANSI B16.5 and MIL-F-20042, and second, incompatibility of application of flange standards, principally nonferrous[5] flange standards.

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[5]In this report, aluminum systems are not included. Therefore, throughout the report, the term nonferrous is not intended to include aluminum.

6. Flange Dimensional Incompatibility. As indicated in the abstract at the beginning of this report, the major differences between the Mil Spec and ANSI flanges are in their physical dimensions -- that is, diameter and thickness of flange, and size, number and spacing of bolt holes -- which make them incompatible with each other.

To enable the reader to appreciate the differences better, an example is tabulated below that depicts some of the inconsistencies. Correlative data for a 150 psi flange in several sizes are tabulated in four subtables, one subtable each for (1) flange diameter, (2) flange thickness, (3) number of bolt holes, and (4) bolt hole diameter. Each subtable has columns for the two ANSI standards and the one Navy Mil Spec that are of principal interest.

COMPARATIVE DIMENSIONS IN INCHES FOR 150 PSI PRESSURE FLANGES
(ANSI B16.5, MIL-F-20042 and ANSI B16.24)

(1) Flange diameter*

NPS	ANSI B16.5	MIL-F-20042	ANSI B16.24
1	4.25	4.25	4.25
2	6.00	5.56	6.00
4	9.00	7.69	9.00
8	13.50	12.38	13.50
10	16.00	15.00	16.00
12	19.00	17.63	19.00

(2) Flange Thickness (Minimum.)

	ANSI 16.5	MIL-F-20042	ANSI B16.24
1	0.56	0.44	0.38
2	0.75	0.44	0.50
4	0.94	0.50	0.69
8	1.12	0.62	0.94
10	1.19	0.69	1.00
12	1.25	0.75	1.06

(3) Number of bolt holes

NPS	ANSI B16.5	MIL-F-20042	ANSI B16.24
1	4	4	4
2	4	6	4
4	8	8	8
8	8	14	8
10	12	15	12
12	12	18	12

(4) Bolt hole diameter

	ANSI 16.5	MIL-F-20042	ANSI B16.24
1	0.62	0.56	0.62
2	0.75	0.56	0.75
4	0.75	0.56	0.75
8	0.88	0.69	0.88
10	1.00	0.81	1.00
12	1.00	0.81	1.00

* A similar pattern for diameter of bolt circle, also known as pitch circle, could also be shown but is omitted for brevity.

The two ANSI standards specify identical flange dimensions except for thickness. This difference is undoubtedly due to the difference in material (ANSI B16.24 is for bronze, which is not included in ANSI B16.5). The other differences between MIL-F-20042 and the ANSI standards can be summarized by noting that the Navy flange is smaller and uses smaller bolts, but often more bolts. Navy probably optimizes hole spacing; ANSI practice specifies holes in multiples of four. Navy's resulting smaller flanges make the arrangement of systems easier in tight spaces, and have less weight -- and correspondingly less cost, if cost increases with the weight of these expensive materials.

7. Nonferrous Flange Application Incompatibilities. In short, the second preliminary finding indicates that nonferrous applications are not consistent with steel applications, nor are nonferrous applications consistent among themselves. Review of the nonferrous flange application incompatibilities is done by analyzing each of the referenced flange standards and their application. Appendix C summarizes each of the flange standards cited earlier for both ferrous and nonferrous flange standards. To repeat, the two primary dimensional standards are ANSI B16.5 for steel applications, and MIL-F-20042 for bronze. However, not all systems are completely steel or bronze, nor do all systems fall completely within the size and pressure ranges of these two standards, and for these reasons the two standards alone do not suffice. A summary of each of the referenced nonferrous flange standards and its application, together with its relation to either ANSI B16.5 or MIL-F-20042, follows.

a. For MIL-STD-777

(1) Bronze -- MIL-F-20042. Called for in Services A-8, C-1, C-2, D-1, D-2, D-3, G-6, G-7, H-1, H-2, I-1, J-4, J-7, J-8, L-1, M-1, R-1, R-3, R-4, and S-1. The principal standard flange used with bronze valves, fittings, and equipment when silver brazing is permitted.

(2) Bronze -- Dwg 810-1385892. Called for in Services C-1, C-2 (appears to be incorrectly classified as CuNi), D-1, D-3, H-1, H-2, I-1, J-8, M-1 and S-1. Special flange with drilling and outside diameter the same as B16.5 (Class 150) through 24

NPS for use with butterfly valves when silver brazing is permitted.

(3) Copper-nickel -- Dwg 810-4715319. Called for in Services A-8, C-1, C-2, D-1, D-3, I-1, N-1, N-2, and S-1. Socket welded flanges dimensioned to and replacement for MIL-F-20042 when silver brazing and butt welding are not permitted. Also socket welded flanges, dimensioned to Dwg 810-1385892 and ASTM B16.5, for use with butterfly valves when silver brazing is not permitted. MIL-F-20042 (bronze) does not cover copper-nickel.

(4) Copper-nickel -- Dwg 810-1385992. Called for in Services D-1, I-1, J-8, N-1, N-2, S-1, and Y-1. Welding neck flanges dimensioned to and replacement for MIL-F-20042 when silver brazing and socket welding are not permitted. MIL-F-20042 (bronze) does not cover copper-nickel.

(5) Bronze -- MIL-F-24227. Called for in Services H-1, H-2, and I-1. Special silver brazing flanges dimensioned same as MIL-F-20042 but undrilled. For use where ultrasonic inspection is required.

(6) Copper-nickel -- ANSI B16.5. Called for in Services D-2 and J-4. Special welded flange dimensioned to ANSI B16.5 (Class 400) for connecting nonferrous piping to commercial valves (D-2) and dimensioned to ANSI B16.5 (Class 150) for connecting nonferrous piping to ferrous piping flanges (J-4) when silver brazing is not permitted.

(7) Bronze -- ANSI B16.24. Called for in Service J-4. Special silver brazed flange dimensioned to ANSI B16.24 for connecting nonferrous piping to ferrous piping flanges.

(8) Bronze -- Dwg 810-1385915. Called for in Services A-8, C-2, D-3, and R-1. Variety of fittings with flanges dimensioned to MIL-F-20042.

(9) Nickel-Copper Alloy -- ANSI B16.5. Called for in Services A-9 and A-10. Dimensions to ANSI B16.5, which includes nickel-copper. Initially, in these systems all piping and flanges were steel and in accordance with ANSI B16.5. To combat

corrosion in these services, however, they were changed to nickel-copper. ANSI B16.5 dimensions were retained for compatibility with other system steel flanges with which they must mate. ANSI B16.5 includes nickel-copper alloy flanges.

(10) Nickel-Copper Alloy -- MS 18308. Called for in Service A-9. Socket welded flanges modified to include nickel-copper alloy material. Covers sizes 1/4 and 3/8 inch, which are smaller than those included in ANSI B16.5.

b. For MIL-STD-438

(1) Bronze -- MIL-F-20042. Called for in Services B-1, B-2, C-2, F-4, F-5, N, and O. The principal standard used with bronze valves, fittings, and equipment when silver brazing is permitted.

(2) Bronze -- Dwg 810-1385947. Called for in Service H-2. Silver-brazing flange for higher pressure (to 700 psi) and ultrasonic inspection. Dimensions differ from MIL-F-20042 owing to higher pressure.

(3) Copper-Nickel -- Dwg 810-1385992. Called for in Services B-1 and O. Welding neck flanges dimensioned to and replacement for MIL-F-20042 (250 psi) when silver brazing is not permitted. Needed since MIL-F-20042 does not cover copper-nickel.

(4) Nickel-Copper -- Dwg 810-1385861. Called for in Service H-2. Welding neck flanges for higher pressure (to 700 psi) where silver brazing is not permitted. Dimensions differ from MIL-F-20042 because of higher pressure.

(5) Copper-Nickel -- ANSI B16.5. Called for in Service C-2. Socket or butt weld flat face flange with drilling and outside diameter in accordance with MIL-F-20042. (Better standard would have been Dwg 810-4715319 for socket welded flanges or Dwg 810-1385992 for welded flanges since ANSI B16.5 does not include materials or dimensions for this application.)

(6) Nickel-Copper Alloy -- ANSI B16.5. Called for in Service

(6) Nickel-Copper Alloy -- ANSI B16.5. Called for in Service A-2. Dimensions to ANSI B16.5, which includes nickel-copper. Initially, in these systems, all piping and flanges were in accordance with ANSI B16.5. To combat corrosion in these services however, they were changed to nickel-copper. ANSI B16.5 dimensions were retained for compatibility with other system steel flanges with which they must mate. ANSI B16.5 includes nickel-copper alloy flanges.

8. Reasons for Incompatibility. Review of the above reveals that the basic reasons for lack of compatibility within nonferrous applications can be summarized as follows:

(1) Since MIL-F-20042 is for bronze only, which must be silver brazed, additional standards are invoked to permit welding to copper-nickel. (Dwg 810-4715319, Dwg 810-1385992, ANSI B16.5).

(2) Since the MIL-F-20042 configuration is not compatible with butterfly valves, which require a larger bolt circle to accommodate the butterfly configuration, additional standards are invoked. (Dwg 810-1385892 (bronze) and Dwg 810-4715319 (copper-nickel)).

(3) Since MIL-F-20042 is good for pressures only up to 400 psi, additional standards are invoked for higher pressure applications. (Dwg 810-1385947 for silver brazing and Dwg 810-1385861 for welding.)

(4) Since MIL-F-20042 covers a flange configuration only, an additional standard is invoked to cover a variety of flanged fitting configurations drilled to MIL-F-20042 (Dwg 810-1385915).

(5) Since MIL-F-20042 is not designed for ultrasonic inspection, additional standards are invoked to cover this configuration (MIL-F-24227 (400 psi) and Dwg 803-1385947 (700 psi)).

(6) Systems formerly all steel, but later modified to provide nickel-copper piping where seawater might be introduced, retain flanges that are consistent with the steel standard (ANSI B16.5) rather than with the nonferrous standard (MIL-F-20042).

Review of all these standards in this way also reveals an inconsistency in the application of the steel flange standard, ANSI B16.5 as well. Since ANSI B16.5 does not cover sizes smaller than 1/2 inch, an additional standard is invoked to cover 1/4 and 3/8 inch sizes, namely MS 18308. Moreover, as explained earlier, MIL-F-20670 is for a steel flange with MIL-F-20042 (bronze) dimensions used to mate steel pipe to bronze valves in Services Y-2 and Y-3 (tank overflows. etc).

9. Preliminary Standardization Considerations. Since the stated objective is "... commercialization of Navy pipe flange patterns..." the next step is to determine what needs to be done with the Navy standards identified, in order to meet this objective. The primary interest would be to merge the Navy's MIL-F-20042 into a commercial standard, either ANSI B16.5 (steel) or ANSI B16.24 (bronze). This merging is especially pertinent with respect to ANSI B16.5 since ANSI B16.5, with but minor exceptions, fully covers the Navy's steel flange requirements. Such commercialization is an intended result of the Navy Document Conversion Program as well as the objective of this project. Furthermore, this particular Mil Spec, MIL-F-20042, applies to surface ships and to submarines as well. However, other standards that have been identified as augmenting MIL-F-20042 in nonferrous applications must also be considered. Therefore the first consolidation of standards would be to incorporate the requirements of those standards into MIL-F-20042. If this is not feasible, then to merge them into ANSI B16.5 or ANSI B16.24 would probably not be feasible, either. Thus the first standardization step is to examine what needs to be done to consolidate all nonferrous flange requirements within MIL-F-20042. Once this consolidation were effected, there would remain but one Navy nonferrous flange standard, namely MIL-F-20042, and two principal commercial flange standards, namely ANSI B16.5 for steel and ANSI B16.24 for bronze. The next step would then be to investigate the feasibility of merging the consolidated MIL-F-20042 into either one of the two ANSI standards.

10. Consolidation of All Nonferrous Standards into MIL-F-20042. The first step in consolidating all Navy nonferrous standards into MIL-F-20042 would require the following:

(1) Include copper-nickel in MIL-F-20042 the flange requirements from Dwg 810-1385892, Dwg 810-1385992 and Dwg 810-4715319. Add requirements to cover any missing copper-nickel flange requirements.

(2) Include in MIL-F-20042 the increased pressure requirements from Dwg 810-1385947 and Dwg 810-1385861. Add additional requirements to cover the range between 400 psi and 700 psi.

(3) Include in MIL-F-20042 the butterfly valve compatible flanges from Dwg 810-1385892 and Dwg 810-4715319. Add additional requirements to cover any missing butterfly valve compatibility requirements.

(4) Include in MIL-F-20042 the ultrasonic inspection features from Dwg 803-1385947 and MIL-F-24227.

(5) Include in MIL-F-20042 the bronze fittings requirements from Dwg 810-1385915.

This consolidation effort would be no small undertaking, and its advisability should be determined by cognizant Naval engineering administrators.

A significant advantage in this approach is that a detailed search of all the affected systems is not required. Cancellation of the standards whose requirements had been merged into MIL-F-20042, with concomitant notification that the requirements had been relocated in the revised MIL-F-20042, would be a simple, straightforward routine procedure. It would also be especially opportune in view of new construction, maintenance, and supply considerations. All the required changes are mainly in paper work. Since all of the physical requirements must be met, and since no duplication would result from merging standards, there should be little or no direct impact on hardware to affect their present status. However, it is not in fact, standardization, merely consolidation.

Two exceptions would prevent the totally revised MIL-F-20042 from being the single Navy nonferrous standard. The first exception occurs in the previously discussed Services A-9 and A-10 for surface ships and A-2 for submarines where nickel-copper flanges are dimensioned in accordance with ANSI B16.5 to mate with remaining steel fittings of the systems. The second exception is in the reference to ANSI B16.24 for Service J-4. (Air and

Nitrogen, to 200 psi) to interface with commercial valves and equipment when commercial valves and equipment are approved for use.

11. Consolidation and Standardization of Nonferrous and Ferrous Standards. Assuming the consolidation of all Navy nonferrous standards within MIL-F-20042 as feasible and complete, the next step is to look at merging MIL-F-20042 into either ANSI B16.5 or ANSI B16.24. Since ANSI B16.24's application is limited at present to only two pressures and to one material, bronze, let us assume the wiser move would be to merge MIL-F-20042 into ANSI B16.5. However, in doing this to meet the objective stated there would be a requirement in the merger that the MIL-F-20042 dimensions be changed to coincide with those of ANSI B16.5. That would be the prime standardization objective, to remove all flange dimensional incompatibilities. This redimensioning would therefore require a complete redesign of all MIL-F-20042 flanges. A further very significant ramification would be to identify all the valves, equipment, and fittings, that these flanges are designed to match. These would likewise have to be changed over time, to effect the standardization objective. These consequences have not been discussed thus far because it is only after this decision point that this issue arises. Literally thousands of parts, components, and equipments would be affected, not only the paper documentation. Identification and evaluation of the following would be required:

- Identity (by kinds and numbers) of all valves, equipments, and fittings affected.
- Impact of the change on new construction.
- Impact of the change on maintenance of existing systems, equipments, valves, and fittings which include present standard flanges.
- Impact of the change on the supply system.

12. Reconsideration of standardization objective. Before continuing this project by proceeding into such an extensive effort as just described, it is believed results of the analysis done to this point warrant reconsideration of the objective. Succinctly put, these results tend to discredit the stated assumptions on which the problem is based.

It is true that there are differences between Navy and commercial flanges, but for use in steel systems, the Navy almost uniformly specifies the commercial standard, ANSI B16.5. The only exceptions are where the Navy has deliberately chosen to place dissimilar materials side by side (as in Services Y-2 and Y-3) or where the Navy requires smaller sizes (1/4 and 3/8 inch) than are specified in ANSI B16.5. This latter exception could be obviated by issuing a simple amendment to ANSI B16.5 if ANSI were willing to do so.

As for nonferrous standards, while more of them exist, judicious consolidation efforts could eliminate several because their purpose is only to fill voids in the primary standard, MIL-F-20042. At present MIL-F-20042 covers only bronze flanges suitable for silver brazing and usable in systems in which the working pressure does not exceed 400 psi. In only the one case, where the Navy has consciously chosen to mix materials (Services A-9 and A-10 for surface ships and A-2 for submarines), is there a need to mix flange standards to accommodate that choice.

In summary, there are two parallel flange systems that are dimensionally inconsistent. While some improvements in both appear feasible with little negative impact, no evidence can be found that mandates that the two become one. On the contrary, a huge negative impact can be visualized if the two are merged into one. This impact will be felt in new construction, maintenance, and supply related to thousands of valves, equipment, and fittings over an extended period of time.

MIL STD 777 - FLANGE DATA

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
A-1	Steam & Steam Drains	1500 (1000°F)	ASTM C.M. Alloy Steel	ANSI B16.5
A-2	Steam & Steam Drains	1500 (775°F)	ASTM Carbon Steel	ANSI B16.5
A-3	Sat. Steam & Steam Drains	600 - 1500	ASTM Carbon Steel	ANSI B16.5
A-4	Steam & Steam Drains	600 (875°F)	ASTM C.M. Alloy Steel	ANSI B16.5
A-5	Steam & Steam Drains	600 (775°F)	ASTM Carbon Steel	ANSI B16.5
A-6	Steam & Steam Drains	150	ASTM Carbon Steel	ANSI B16.5
A-7	Steam	100	ASTM C.M. Alloy Steel	ANSI B16.5
A-8	Steam, Aux Boiler	150	CuNi Bronze Bronze Fitting	Dwg. 810-4715319 MIL-F-20042 Dwg. 810-1385915
A-9	Steam Syst. O.B. Discharge	1500/600	NiCu Alloy NiCu Alloy NiCu Alloy	Commercial MS18308 ANSI B16.5
A-10	HP Steam Drains	100	ASTM CRES	ANSI B16.5
B-1	Feed Systems	600/1200	ASTM Carbon Steel	ANSI B16.5
B-2	Sat. Feed Syst.	600-2050	ASTM Carbon Steel	ANSI B16.5
C-1	F.W. & Elex. F.W. Cool	200	CuNi Bronze Bronze GRP	Dwg. 810-4715319 MIL-F-20042 Dwg. 810-1385892 MIL-P-24608
C-2	Feed Water	100	Bronze CuNi CuNi Bronze Fitting GRP	MIL-F-20042 Dwg. 810-1385892 Dwg. 810-4715319 Dwg. 810-1385915 MIL-P-24608

MIL STD 777 - FLANGE DATA - Continued

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
D-1	S.W., Drainage, Ballast	250	Bronze	MIL-F-20042
			Bronze	Dwg. 810-1385892
			CuNi	Dwg. 810-1385992
			CuNi	Dwg. 810-4715319
			GRP	MIL-P-24608
D-2	S.W. Drainage, Ballast	400	Bronze	MIL-F-20042
			CuNi	ANSI B16.5
D-3	Sea Water	50	Bronze	MIL-F-20042
			Bronze	Dwg. 810-1385892
			CuNi	Dwg. 810-4715319
			Bronze Fitting	Dwg. 810-1385915
			GRP	MIL-P-24608
E-1	Fuel	1200	ASTM Carbon Steel	ANSI B16.5
E-2	Fuel	600	ASTM Carbon Steel	ANSI B16.5
E-3	Fuel	200	ASTM Carbon Steel	ANSI B16.5
			ASTM Carbon Steel	ANSI B16.5
E-4	Fuel (G.T. Ships)	200	ASTM CRES	ANSI B16.5
F-1	Lube Oil	150	ASTM Carbon Steel	Commercial
			ASTM Carbon Steel	ANSI B16.5
G-1	Steam Catapult, Hyd. Oil	3000	ASTM Carbon Steel	ANSI B16.5
G-2	Steam Catapult, Hyd. Oil	200	ASTM Carbon Steel	ANSI B16.5
G-3	Hydraulic Oil, Other	3000	ASTM Carbon Steel	ANSI B16.5
			ASTM CRES	ANSI B16.5

MIL STD 777 - FLANGE DATA - Continued

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
G-4	Hydraulic Oil, Other	1500	ASTM Carbon Steel	ANSI B16.5
			ASTM CRES	ANSI B16.5
G-5	Hydraulic Oil, Other	900	ASTM Carbon Steel	ANSI B16.5
			ASTM CRES	ANSI B16.5
G-6	Hydraulic Oil, Other	300	Bronze	MIL-F-20042
			ASTM Carbon Steel	ANSI B16.5
			ASTM CRES	ANSI B16.5
G-7	Hydraulic Oil, Other	150	Bronze	MIL-F-20042
			ASTM Carbon Steel	ANSI B16.5
H-1	Gasoline	150	Bronze	MIL-F-20042
			Bronze	MIL-F-24227
			Bronze	Dwg. 810-1385892
H-2	Cleaning Fluid	100	Bronze	MIL-F-20042
			Bronze	MIL-F-24227
			Bronze	Dwg. 810-1385892
I-1	JP-5	200	Bronze	MIL-F-20042
			Bronze	MIL-F-24227
			Bronze	Dwg. 810-1385892
			CuNi	Dwg. 810-1385992
			CuNi	Dwg. 810-4715319
J-1	Air, Nitrogen & Helium	6000	No Flanges	
J-2	Air & Nitrogen	3300	No Flanges	
J-3	Air & Nitrogen	600	No Flanges	
J-4	Air & Nitrogen	200	Bronze	MIL-F-20042
			Bronze	ANSI B16.24
			ASTM CRES	ANSI B16.5
			GRP	MIL-P-24608
J-5	Air, A/C Starting	150	ASTM Carbon Steel	ANSI B16.5

MIL STD 777 - FLANGE DATA - Continued

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
J-6	Air, A/C Starting	150	ASTM CRES	ANSI B16.5
J-7	Air, Prairie-Masker	100	Bronze CuNi CRES	MIL-F-20042 ANSI B16.5 ANSI B16.5
J-8	Air Deballast	50	Bronze Bronze CuNi	MIL-F-20042 Dwg. 810-1385892 Dwg. 810-1385992
J-9	Air, GT Bleed	200	ASTM CRES	ANSI B16.5
K-1	Gaseous Oxygen, Outside Hull	4500	No Flanges	
K-2	Gaseous Oxygen, Inside Hull	4500	No Flanges	
K-3	Gaseous Oxygen	100	No Flanges	
K-4	Liquid Oxygen & Nitrogen	6000	No Flanges	
K-5	Liquid Oxygen & Nitrogen	250	No Flanges	
K-6	Mixed Gas	4500	No Flanges	
K-7	Propane	200	No Flanges	
L-1	Cooling, (Elex. Equipment, Diesel Engines)	150	ASTM CRES Bronze	ANSI B16.5 MIL-F-20042
M-1	Sea Water Washdown	200	Bronze Bronze	MIL-F-20042 Dwg. 810-1385892
N-1	Sprinkling System (Dry)	175	CuNi CuNi	Dwg. 810-4715319 Dwg. 810-1385992
N-2	Magazine Sprinkling (Wet)	175	CuNi CuNi	Dwg. 810-4715319 Dwg. 810-1385992
O-1	Diesel, Sewage Treatment Incin. & GT Exhaust	-	ASTM CRES ASTM CRES	ANSI B16.5 ANSI B16.5

MIL STD 777 - FLANGE DATA - Continued

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
P-1	Boiler Safety Valve	150	ASTM Carbon Steel	ANSI B16.5
Q-1	Refrigerant Piping	30 in. vac to 300	ASTM Steel Brass	 Commercial
R-1	Waste & Oily Water	50	Bronze GRP ASTM Carbon Steel Bronze Fitting	MIL-F-20042 MIL-P-24608 ANSI B16.5 Dwg. 810-1385915
R-2	Chemical Drains	30	ASTM CRES	ANSI B16.5
R-3	Drains & Vents	50	Bronze	MIL-F-20042
R-4	Sewage Collection (HT)	50	Bronze	MIL-F-20042
S-1	AFFF Concentrate & Solution	250	Bronze Bronze CuNi CuNi	MIL-F-20042 Dwg. 810-1385892 Dwg. 810-1385992 Dwg. 810-4715319
T-1	Fixed CO_2 Inerting	1900	No Flanges	
T-2	HALON 1301 Distribution	2010/1170	ASTM Carbon Steel	ANSI B16.5
T-3	HALON 1301 Actuation	2010	No Flanges	
U-1	Stripping, Fuel	150	ASTM Carbon Steel	ANSI B16.5
V-1	Voice Tubes	-	No Flanges	
W-1	Pheumatic Tubes	-	No Flanges	
Y-1	Overflows, Sounding Tubes etc. for JP-5 Tanks	50	CuNi	Dwg. 810-1385992

MIL STD 777 - FLANGE DATA - Continued

	Service	Maximum System Pressure (psi)	Material	Applicable Documents
Y-2	Overflows, Sounding Tubes etc. for Fuel Tanks	50	ASTM Carbon Steel	ANSI B16.5
			ASTM Carbon Steel	MIL-F-20670
Y-3	Overflows for other than Fuel Tanks	50	ASTM Galv. Carbon Steel	ANSI B16.5
			ASTM Galv. Carbon Steel	MIL-F-20670
Y-4	Vents, Reduction Gear	5	No Flanges	

MIL STD 438E - FLANGE DATA

	Service	Design Pressure (psig)	Material	Applicable Documents
A-2	Steam & High Pressure Steam Drains	400 - 1100	ASTM F.C. Steel	ANSI B16.5
	Feed Water	600 - 1300	NiCu-QQ-N-281	ANSI B16.5
A-4	Steam & Low Pressure Steam Drains	165	ASTM F.C. Steel	ANSI B16.5
B-1	Low Pressure Steam Drains, Condensate & Other F.W. Services	165	Bronze CuNi	MIL-F-20042 Dwg. 810-1385992
B-2	Battery Fresh Water	100	Bronze	MIL-F-20042
C-1	Sea Water	–	–	IAW Ship Specifications
C-2	Sea Water	100	Bronze CuNi	MIL-F-20042 ANSI B16.5 (Drill IAW 20042)
D-1	Oil Systems (other than hydraulic)	151 - 1000	ASTM F.C. Steel	ANSI B16.5
D-2	Oil Systems (other than hydraulic)	150	ASTM F.C. Steel ASTM C.C. Steel	ANSI B16.5 ANSI B16.5
E-1	Hydraulic Service (Inside P.H.)	3000	CuNi CRES Bronze CRES	As Approved As Approved As Approved As Approved
E-2	Hydraulic Service (Outside P.H.)	3000	CuNi CRES	As Approved As Approved
E-3	Low Pressure Hydraulic System (Inside P.H.)	700	CuNi CRES	As Approved As Approved
F-1	Air & Nitrogen	6000	No Flanges	
F-2	Air, Nitrogen & Helium	3000	No Flanges	
F-3	Air & Nitrogen	1500	No Flanges	
F-4	Air & Nitrogen	400	Bronze	MIL-F-20042

MIL STD 438E - FLANGE DATA - Continued

	Service	Design Pressure (psig)	Material	Applicable Documents
F-5	Control Air, Air & Nitrogen	100	Bronze	MIL-F-20042
F-6	Salvage Air Inboard of Hull Valve	50	No Flanges	
F-7	Battery Electrolyte Agitation	50	ASTM Polyvinyl-chloride	Commercial
G-1	Diesel Engine Exhaust, Inboard	30	NCMC Alloy	ANSI B16.5
G-2	Diesel Engine Exhaust, Outboard	Free Flood	NCMC Alloy	ANSI B16.5
H-1	Ventilation Exhaust & Low Press. Blow (Inboard)	20	Carbon Steel	ANSI B16.5
H-2	Low Press. Blow (Outboard)	Int. 20 Ext., Ship Spex	Bronze NiCu	Dwg. 810-1385947 Dwg. 810-1385861
J-1	Reefer Plant	2 in. vac to 125	Steel Brass	Sil. Braze, 4 Bolt, T&G Sil. Braze, 4 Bolt, T&G
J-2	Reefer Piping	30 in. vac to 50	Steel Brass	Sil. Braze, 4 Bolt, T&G Sil. Braze, 4 Bolt, T&G
K-1	Oxygen & Hydrogen	3000	No Flanges	
K-2	Oxygen	100	No Flanges	
N	Elex. F.W. Cooling	100	Bronze	MIL-F-20042
O	Vents-Reduction Gear	50	Bronze CuNi	MIL-F-20042 Dwg. 810-1385992

Document summary. A summary of the documents listed earlier which are referenced in MIL-STD-777 and MIL-STD-438 for non-ferrous materials follows:

- ANSI B16.5 - This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, testing, and methods of designating openings for pipe flanges and flanged fittings in sizes NPS 1/2 through NPS 24 and in rating classes 150, 300, 400, 600, 900, 1500 and 2500. It does not include bronze.

- ANSI B16.24 - This standard is for bronze pipe flanges (threaded or blind) and flanged fittings, Class 150 (1/2 - 12 nps) and 300 (1/2 - 8 nps) and covers pressure-temperature ratings, sizes and method of designating openings of reducing fittings, marking, minimum requirements for materials, dimensions and tolerances, bolts, nuts, and gaskets, threading and facings. Dimensions, except for thickness, correspond to those prescribed in ANSI B16.5.

- MIL-F-20042 - This specification covers 50, 100, 150, 250, and 400 pound silver brazing bronze pipe and bulkhead flanges for use with water, oil, gas, or steam service, not to exceed 425 degrees Fahrenheit (°F). Sizes include 1/4 to 40 inches. It is the principal nonferrous flange standard since many Navy standards invoke it. It is totally incompatible with ANSI B16.5 and ANSI B16.24.

- MIL-F-20670 - This specification covers 50, 100, 150 and 200 psi carbon steel pipe flanges from 1/4 through 20 inch nominal size. For 10 inches and smaller, 150 psi maximum for 301°F to 775°F maximum and 200 psi maximum for 300°F and below. For over 10 inches, 50 psi maximum for 301°F To 775°F maximum, and 100 psi maximum for 300°F and below. Drilling is equal to MIL-F-20042 (150 psi) for interface with bronze flanges and fittings.

- MIL-F-24227(SHIPS) - This specification covers tube fittings and flanges of cast bronze with ends for silver-brazing into a piping system, suitable for ultrasonic inspections. The flanges are undrilled but dimensions, except thickness, correspond to those of MIL-F-20042.

- Drawing 810-1385892 - Flanges, Bronze, Special, for Use with Butterfly Valves covers 150 psi flanges from IPS 1/2" to IPS 20" and 50 psi flanges from IPS 22" to IPS 46". Dimensions of 150 psi flanges are consistent with those specified in ANSI B16.5 except for thickness. 50 psi flanges are not included in ANSI B16.5. Special for use with butterfly valves.

- Drawing 810-1385992 - Flanges, CuNi, 250 psi to 150 °F or 200 psi to 425 °F, WOG, Welding Neck, covers 2 to 24 inches NPS. Pitch circle, diameter, and number of holes similar to MIL-F-20042 except for 15 nps flange which is not included in MIL-F-20042.

- Drawing 810-1385947 - Flanges, Bronze, 700 psi, WOG, for UT Insp, covers 700 psi flanges from NPS 1/4" to 8". Similar to but differs from MIL-F-20042 due to higher pressure.

- Drawing 810-1385861 - Flanges, Sea Water, 700 psi max. Dimensions similar to but not consistent with MIL-F-20042 due to higher pressure.

- Drawing 810-4715319 - NNSY Type Plan - Standard Flanges CuNi Socket Welded sizes include 2 to 18 inches covers flanges for 50, 150, 200, and 250 psi for WOG services where silver brazing is not permitted. Invokes MIL-F-20042 for OD, thickness and drilling and Dwg 810-1385892 for use with butterfly valves where silver brazing is not permitted.

- MS 18308 - Alloy Steel Socket Welding Flanges and Flanged Nipples, 1/4 inch and 3/8 inch, 600 psi at 850°F 750 psi at 425 °F max, 800 psi at 360 °F and 900 psi. Dimensions and drilling not consistent with ANSI B16.5 due to size less than 1/2 inch NPS. Material modified to nickel-copper alloy.

- Drawing 810-1385915 - Fittings, Pipe, Composition, Flanges, 100 psi Max, at 450 °F Max for All Services. Fittings are bronze, flanges are drilled to MIL-F-20042 (150 psi).

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