SAE INTERNATIONAL

AEROSPACE STANDARD

AS20708 REV. B

Issued 1999-08
Revised 2014-10

Superseding AS20708A

(R) Synchros, General Specification For

RATIONALE

In view of the discontinued use by manufacturers of “GO-NO GO” gages for inspections of splines, the requirement for inspection is revised (see 3.4.4). This revision also provides deletion and addition of applicable documents, clarification of qualification and first article test information, replacements for an obsolete MS17182 (see Note 4 for Figures 5 through 9), and updates to Index.

1. SCOPE

1.1 Scope

This specification relates to Synchros, 60 and 400 Hz. It is not complete in itself, but shall be used in conjunction with MIL-DTL-81963, in which the latter shall be recognized as forming an inherent part of this specification. This standard requires a Qualified Products List (see 6.4).

1.2 Classification

1.2.1 Nomenclature

The nomenclature shall consist of the item name, followed by a type designation including a modification letter and a military part number. All synchros having the same design nomenclature shall be physically, mechanically, and electrically interchangeable for all military applications. The type designation shall be indicated by a combination of digits and letters. The type designation of 26-V synchros shall be preceded by “26V”. The complete nomenclature of a size 15, 115-V, 400-Hz Synchro Transmitter is illustrated in Table 1. Nomenclature for new synchro types will be assigned by the Naval Air Systems Command, Department of the Navy.

1.2.1.1 Item Name - (see 6.5.1)

The item name shall be one of the following, as applicable:

Synchro Transmitter
Synchro Receiver
Synchro Differential Transmitter
Synchro Differential Receiver
Synchro Control Transformer
Synchro Receiver Transmitter

However, on small synchros where space is insufficient for the full item name, the words “Differential” and “Control” may be omitted.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AS20708B

1.2.1.2 Size

The first two digits shall designate the maximum diameter in tenths of an inch. If the diameter is not exactly a whole number of tenths, the next higher tenth shall be used.

1.2.1.3 Function

The succeeding group of letters shall indicate the function in accordance with the following:

First Letter	Function
C	Control
T	Torque

Succeeding Letters	Function
D	Differential
R	Receiver
T	Transformer
X	Transmitter
B	Rotatable Stator

When two synchros are enclosed within the same housing, the nomenclature shall indicate both units; e.g., 37TR-TR6A.

1.2.1.4 Supply Frequency

The succeeding digit shall indicate the frequency of the power in accordance with the following:

Supply Frequency (Hz)	Code
60	6
400	4

1.2.1.5 Design Modification

An upper case letter “A” following the frequency digit shall indicate the original or basic design of a standard synchro type. The first modification that affects the external mechanical dimensions or the electrical characteristics of the basic type shall be indicated by the upper case letter “B”. Succeeding design modifications shall be indicated by “C”, “D”, etc., except “I”, “L”, “O”, and “Q” shall not be used.

1.2.1.6 Military Part Number

The military part numbershall consist of the letter “M”, the basic number of the specification sheet (not including the revision letter), an assigned dash number and a suffix letter designating the latest modification letter in the type designation, as shown in the following example:

M	20708/14	-01	D
Military Designator	Specification Sheet Number	Dash Number	Latest Modification Letter

1.3 Illustration

A synchro classified as 15CX4D - M20708/14-01D (see Table 1) indicates the third modification to the original design of a 115-V, 400-Hz synchro control transmitter whose body diameter is greater than 1.40 inches but not greater than 1.50 inches, and the military part number specifies that this synchro has a splined shaft and terminal connections. A 26-V synchro classified as 26V-11TX4C - M20708/ 6-01C indicates the second modification to the original design of a 26-V, 400-Hz synchro torque transmitter whose body diameter is greater than 1.00 inch but not greater than 1.10 inches, and the military part number specifies that this synchro has a splined shaft and terminal connections.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS7928/12 Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell Mouthed, Tin Whisker, Type II, Class 1, (for 105°C Total Conductor Temperature)

AS20708/1 Synchro, Control Transformer, Type 11CT4E

AS20708/2 Synchro, Control Transmitter, Type 11CX4E

AS20708/3 Synchro, Torque Receiver, Type 11TR4C

AS20708/4 Synchro, Torque Transmitter, Type 11TX4C

AS20708/5 Synchro, Torque Receiver, Type 26V-11TR4C

AS20708/6 Synchro, Torque Transmitter, Type 26V-11TX4C

AS20708/7 Synchro, Control Transformer, Type 26V-11CT4D

AS20708/8 Synchro, Control Transmitter, Type 26V-11CX4C

AS20708/9 Synchro, Control Differential Transmitter, Type 26V-11CDX4C

AS20708/14 Synchro, Control Transmitter, Type 15CX4D

AS20708/15 Synchro, Control Transformer, Type 15CT4C

AS20708/16 Synchro, Control Differential Transmitter, Type 15CDX4D

AS20708/17 Synchro, Torque Differential Transmitter, Type 15TDX4C

AS20708/19 Synchro, Torque Receiver Transmitter, Type 15TRX4A

AS20708/20 Synchro, Control Transmitter, Type 15CX6C

AS20708/21 Synchro, Control Transformer, Type 15CT6D

AS20708/22 Synchro, Control Differential Transmitter, Type 15CDX6C

AS20708/23 Synchro, Torque Receiver Transmitter, Type 15TRX6A

AS20708/25 Synchro, Control Transformer, Type 16CTB4B

AS20708/28 Synchro, Control Transmitter, Type 18CX4D

AS20708/29 Synchro, Control Transformer, Type 18CT4C

AS20708/30 Synchro, Control Differential Transmitter, Type 18CDX4C

AS20708/31 Synchro, Torque Differential Transmitter, Type 18TDX4C

AS20708/32 Synchro, Torque Receiver Transmitter, Type 18TRX4A

AS20708/33 Synchro, Control Transmitter, Type 18CX6C

AS20708/34 Synchro, Control Transformer, Type 18CT6D

AS20708/35 Synchro, Torque Receiver Transmitter, Type 18TRX6B

AS20708/36 Synchro, Control Differential Transmitter, Type 18CDX6D

AS20708/39 Synchro, Control Transformer, Type 19CTB4B

AS20708/45 Synchro, Control Transmitter, Type 23CX4D

AS20708/46 Synchro, Control Transformer, Type 23CT4C

AS20708/47 Synchro, Control Differential Transmitter, Type 23CDX4C

AS20708/48 Synchro, Torque Differential Transmitter, Type 23TDX4C

AS20708/49 Synchro, Torque Differential Receiver, Type 23TDR4B

AS20708/50 Synchro, Torque Receiver Transmitter, Type 23TRX4A

AS20708/52 Synchro, Control Transmitter, Type 23CX6D

AS20708/53 Synchro, Control Transformer, Type 23CT6D

AS20708/54 Synchro, Control Differential Transmitter, Type 23CDX6C

AS20708/55 Synchro, Torque Differential Transmitter, Type 23TDX6C

AS20708/56 Synchro, Torque Receiver Transmitter, Type 23TRX6B

AS20708/62 Synchro, Torque Receiver Transmitter, Type 31TRX4A

AS20708/66 Synchro, Torque Receiver Transmitter, Type 31TRX6A

AS20708/67 Synchro, Torque Differential Receiver, Type 31TDR6B

AS20708/68 Synchro, Torque Differential Transmitter, Type 31TDX6C

AS20708/70 Synchro, Torque Receiver Transmitter, Type 37TRX4A

AS20708/74 Synchro, Torque Receiver Transmitter, Type 37TRX6A

AS20708/76 Synchro, Torque Differential Transmitter, Type 37TDX6A

AS20708/78 Synchro, Control Transmitter, Type 26V-08CX4C

AS20708/79 Synchro, Control Transformer, Type 26V-08CT4C

AS20708/80 Synchro, Control Differential Transmitter, Type 26V-08CDX4C

AS20708/81 Synchro, Control Differential Transmitter, Type 11CDX4B

AS20708/94 Synchro, 60 and 400 Hz, 23

AS20708/131 Synchro, Control Transmitter, Type 15CX4F

AS20708/139 Synchro, Control Transmitter, Type 31CX6A

AS20708/500 Synchro, Torque Receiver, Type 26V-10TR4

AS25036 Terminal, Lug. Crimp Style, Copper, Insulated, Ring Tongue, Bell-Mounted, Type II, Class 1, (For 105 Degrees C Total Conductor Temperature)

2.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI/NEMA MW HP-3 Electrical and Electronic PTFE (Polytetrafluoroethylene) Insulated High Temperature Hook-Up Wire; Types ET (250 Volts), E (600 Volts) and EE (1000 Volts)

2.3 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM35275 Screw, Machine-Drilled Fillister Head, Slotted, Corrosion Resisting Steel, Passivated, UNC-2A

NASM35276 Screw, Machine-Drilled Fillister Head, Slotted, Corrosion Resisting Steel, Passivated, UNF-2A

NASM35338 Washer, Lock-Spring, Helical, Regular (Medium) Series

2.4 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, http://quicksearch.dla.mil/.

2.4.1 Specifications and Standards

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATION

MIL-DTL-81963 Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests: General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MS17183 Clamp Assembly (Synchro)

MS17186 Washer, Drive (Synchro)

MS17187 Nut, Plain, Hexagon

2.5 Order of Precedence

Unless otherwise noted herein or the contract, in the event of a conflict between the text of this document and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations, unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification Sheets

The individual item requirements shall be as specified herein, MIL-DTL-81963, and in accordance with the applicable specification sheets. In the event of any conflict between requirements of MIL-DTL-81963, this specification, and the specification sheet, the latter shall govern.

3.2 Qualification

Synchros furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.5 and 6.4).

3.3 First Article

When a source for a qualified product is not available and first article inspection is required by the contracting activity, a sample shall be subjected to first article inspection in accordance with the requirement of the applicable specification sheet (see 3.1, 4.6, and 6.3).

3.4 Design Conventions

3.4.1 Direction of Rotation

The standard (positive) direction of rotation of the shaft is counterclockwise, when the synchro is viewed from the shaft extension end.

3.4.2 Electrical Angle

3.4.2.1 Transmitters and Receivers

The electrical angle “a” is the angle displaced in a positive direction from synchro zero, which satisfies the relative magnitude and polarities of the secondary voltages of an ideal synchro transmitter or receiver in accordance with the following equations:

E(S1S3) = N E(R2R1) sin a
E(S3S2) = N E(R2R1) sin a (a + 120 degrees)
E(S2S1) = N E(R2R1) sin a (a + 240 degrees)

where:

The terminal sequence, as indicated in the parentheses, designates the sense of the voltage vector.
N is the transformation ratio.
E(R2R1) is the voltage between terminals R2 and R1.
E(S1S3) is the voltage between terminals S1 and S3.
The in-time-phase secondary voltages are obtained as described in 6.6.8; other voltages are similarly defined.

3.4.2.2 Differential Transmitters and Differential Receivers

The electrical angle “a” is the angle, displaced in a positive direction from synchro zero, which satisfies the relative magnitude and polarities of an ideal synchro differential transmitter or differential receiver in accordance with the following equations:

E(R1R3) = N (E(S1S3) sin (a + 120 degrees) - E(S3S2) sin a)
E(R3R2) = N (E(S1S3) sin a - E(S3S2) sin (a + 240 degrees))
E(R2R1) = N (E(S1S3) sin (a + 240 degrees) - E(S3S2) sin (a + 120 degees))
E(S1S3) + E(S3S2) + E(S2S1) = 0

where:

The terminal sequence as indicated in the parentheses designates the sense of the voltage vector.
N is the transformation ratio.
E(R2R1) is the voltage between terminals R2 and R1.
E(S1S3) is the voltage between terminals S1 and S3.
The in-time-phase secondary voltages are obtained as described in 6.6.8; other voltages are similarly defined.

3.4.2.3 Control Transformers

The electrical angle “a” is the angle displaced in a positive direction from synchro zero, which satisfies the relative magnitude and polarities of the secondary voltages of an ideal synchro control transformer in accordance with the following equations:

E(R1R2) = N (E(S1S3) sin (a + 120 degrees) - E (E(S3S2) sin a))
E(S1S3) + E(S3S2) + E(S2S1) = 0

where:

The terminal sequence as indicated in the parentheses designates the sense of the voltage vector.
N is the transformation ratio.
E(R1R2) is the voltage between terminals R1 and R2.
E(S1S3) is the voltage between terminals S1 and S3.
The in-time-phase secondary voltages are obtained as described in 6.6.8; other voltages are similarly defined.

3.4.3 Synchro Zero

Synchro zero is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit specified, and at which the secondary voltage(s) specified is in-time-phase (see 6.6.8) with the primary voltage specified (see 4.3.4). The order in terms of maximum voltages in the stator terminals is in the order S1, S2, S3, when the rotor is turned in a positive direction (see 3.4.1). The minimum voltage position with the secondary unloaded is defined as the angular position where the secondary voltage of fundamental frequency that is in-time-phase with the secondary voltage at maximum coupling is zero. The phase-sensitive voltmeters in Figures 1, 2, and 3 shall be the type as described in 4.8.12.

3.4.3.1 Transmitters and Receivers

Synchro zero of transmitters and receivers shall be determined with the synchro connected in accordance with Figure 1. When the synchro shaft is rotated in the positive direction (not to exceed 180 degrees) from synchro zero, the voltage E(S1S3) shall be in approximate time phase with E(R2R1).

3.4.3.2 Differential Transmitters and Differential Receivers

Synchro zero of differential transmitters and differential receivers shall be determined with the synchro connected in accordance with Figure 2. When the synchro shaft is rotated in the positive direction (not to exceed 180 degrees) from synchro zero, the voltage E(R3R1) shall be in approximate time phase with E(S3S2).

3.4.3.3 Control Transformers

Synchro zero of control transformers shall be determined with the synchro connected in accordance with Figure 3. When the synchro shaft is rotated in the positive direction (not to exceed 180 degrees) from synchro zero, the voltage E(R2R1) shall be in approximate time phase with E(S3S2).

3.4.4 Spline Shafts

The end function of the spline on synchros with splined shafts is as a rotational positive fastening. These splines are not to be used as gears. The tooth form shall be full depth involute on all splines. All splines for the different sizes of Synchros with spline shafts (11, 15, 18, 23, 31, and 37) shall be inspected using methods which enable the Synchros to meet the performances requirements of AS20708 and the applicable specification sheet.

3.5 Design and Construction

3.5.1 Termination Identification

Winding terminations shall be as specified in MIL-DTL-81963. Identification of terminal screw, solder pin or wire lead types shall be as specified in Table 2 herein. Each wire lead terminal shall consist of seven strands of silver-coated conductor and shall be 18 inches long minimum or as specified in the applicable specification sheet (see 3.1). For synchro frame sizes 05, wire leads shall conform to NEMA HP 3-ETWBBB* (“*” see Table 2 for color codes). For synchro frame sizes 08, 11, 15, wire leads shall conform to NEMA HP 3-EWBCB*(“*” see Table 2 for color codes).

3.5.2 Synchro Zero Markings

The synchro zero markings shall be checked in accordance with 4.8.2.4 and shall meet the requirements specified in MIL-DTL-81963.

3.5.3 Dimensions

Outline drawings for the different sizes of synchros are included as Figures 4, 5, 6, 7, 8, and 9. Lettered dimensions shown on the outline drawings are provided in Table 3.

3.5.4 Pure Tin

The use of pure tin, as an under plate or final finish, is prohibited both internally and externally. Tin content of indicator components and solder shall not exceed 97%, by mass. Tin shall be alloyed with a minimum of 3% lead, by mass (see 6.10).

3.5.5 Recycled, Recovered, Environmentally Preferable, or Biobased Materials

Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.6 Performance

3.6.1 Visual and Mechanical Inspection

Visual and mechanical inspection shall be performed in accordance with 4.8.1 and shall meet the requirements of MIL-DTL-81963.

3.6.2 Variation of Brush Contact Resistance

Brush contact resistance test shall be conducted in accordance with 4.8.2. This test shall be the first test performed and shall also be the first test performed after environmental tests as indicated in Table 4. The variation in resistance shall be as specified in MIL-DTL-81963.

3.6.3 Shaft Radial and End Play (see 6.6.11)

Shaft radial and end play shall be tested in accordance with 4.8.3 and shall meet the requirements specified in MIL-DTL-81963.

3.6.4 Shaft Runout

When tested in accordance with 4.8.4, shaft runout shall not exceed the value specified in the specification sheet.

3.6.5 Mechanical Breakaway Torque (see 6.6.12)

When tested in accordance with 4.8.5, mechanical breakaway torque shall meet the requirements specified in MIL-DTL-81963.

3.6.6 Torque Gradient (see 6.6.13)

When tested in accordance with 4.8.6, the torque gradient of torque synchros shall conform to the requirements in the applicable specification sheet.

3.6.7 Dielectric Withstanding Voltage

When tested in accordance with 4.8.7, the synchro shall meet the requirements of MIL-DTL-81963.

3.6.8 Insulation Resistance

Insulation resistance measurements shall be performed in accordance with 4.8.8 and shall meet the requirements of MIL-DTL-81963.

3.6.9 Primary Current

When tested in accordance with 4.8.9, the value of the current of each primary winding shall be as specified in MIL-DTL-81963.

3.6.10 Primary Power

When tested in accordance with 4.8.10, the value of the power of each primary winding shall be as specified in MIL-DTL-81963.

3.6.11 Transformation Ratio (see 6.6.9)

When tested in accordance with 4.8.11, the value of transformation ratio shall be as specified in the specification sheet.

3.6.12 Phase Shift (see 6.6.10)

When tested in accordance with 4.8.12, the value of the phase shift shall be as specified in the specification sheet.

3.6.13 Electrical Error (see 6.6.2)

When tested in accordance with 4.8.13, the electrical error shall not exceed the value specified in the specification sheet.

3.6.14 Residual (Null) Voltage (see 6.6.14)

When tested in accordance with 4.8.14, the null voltage shall not exceed the value specified in the specification sheet.

3.6.15 Receiver Error (see 6.6.3)

When tested in accordance with 4.8.15, the maximum error shall not exceed the value specified in the specification sheet.

3.6.16 Spinning

When tested in accordance with 4.8.16, the rotor of a receiver or differential receiver shall synchronize or come to rest from any initial angular position without spinning.

3.6.17 Synchronizing Time (see 6.6.4)

When tested in accordance with 4.8.17, the synchronizing time shall not exceed the value specified in the specification sheet.

3.6.18 Security of Terminals or Wire Leads

The security of each screw type or solder pin type of terminal or of each wire lead, as applicable to the particular type of synchro, shall be tested in accordance with 4.8.18 and shall meet the requirements of MIL-DTL-81963.

3.6.19 Impedance (see 6.6.5)

When measured in accordance with 4.8.19, the impedance values shall be as specified in the specification sheet.

3.6.20 Temperature Rise (see 6.6.16)

When measured in accordance with 4.8.20, temperature rise shall be as specified in MIL-DTL-81963.

3.6.21 Variation of Voltage and Frequency

Synchros shall be capable of operating satisfactorily from power sources subject to a ±10% voltage regulation in combination with frequency variation of ±5%. When tested in accordance with 4.8.21, the power drawn from the source shall not exceed that specified by the specification sheet.

3.6.22 Audible Noise, Structureborne

When required by the applicable specification sheet, structureborne noise shall be tested in accordance with 4.8.22 and shall meet the requirements of MIL-DTL-81963.

3.6.23 Electromagnetic Interference

When required by the applicable specification sheet, electromagnetic interference shall be tested in accordance with 4.8.23 and shall meet the requirements of MIL-DTL-81963.

3.7 Environmental

3.7.1 Vibration

Vibration shall be conducted in accordance with 4.9.1. After vibration the synchros shall meet the requirements of MIL-DTL-81963 and Table 4 herein.

3.7.2 Shock

3.7.2.1 Shock, Specified Pulse

Shock shall be conducted in accordance with 4.9.2.1. After shock synchros shall meet the requirements of MIL-DTL-81963 and Table 4 herein.

3.7.2.2 Shock, High Impact

Shock shall be conducted in accordance with 4.9.2.2. After shock, synchros shall meet the requirements of MIL-DTL-81963 and Table 4 herein.

3.7.3 Altitude

During altitude testing, synchros shall be capable of operation from the low temperature specified in MIL-DTL-81963 to +125 °C. Synchros size 23 and smaller shall meet the requirements of Table 4.

3.7.3.1 Altitude, Low Temperature

Altitude, low temperature, shall be conducted in accordance with 4.9.3.1 and shall meet the requirements of Table 4.

3.7.3.2 Altitude, High Temperature

Altitude, high temperature, shall be conducted in accordance with 4.9.3.2 and shall meet the requirements of Table 4.

3.7.4 Endurance

Endurance shall be conducted in accordance with 4.9.4. After testing, the synchros shall meet the requirements of Table 4.

3.7.5 Ambient Temperature

3.7.5.1 Ambient Low Temperature

The synchro shall be tested in accordance with 4.9.5.1 and shall meet the requirements of Table 4.

3.7.5.2 Ambient High Temperature

The synchro shall be tested in accordance with 4.9.5.2 and shall meet the requirements of Table 4.

3.7.6 Moisture Resistance

Synchros shall be tested in accordance with 4.9.6 and shall meet the requirements of Table 4.

3.7.7 Explosion Resistance

When required by the applicable specification sheet, synchros shall be tested in accordance with 4.9.7 and shall meet the requirements of MIL-DTL-81963.

3.7.8 Salt Atmosphere

When required by the applicable specification sheet, synchros shall be tested in accordance with 4.9.8 and shall meet the requirements of MIL-DTL-81963.

3.7.9 Identification Marking

Identification markings shall be as specified in MIL-DTL-81963.

3.7.10 Workmanship

Workmanship of the synchro shall conform to the requirements of MIL-DTL-81963.

4. VERIFICATION

4.1 Responsibility for Compliance

Responsibility for compliance shall be as specified in MIL-DTL-81963.

4.2 General

Unless otherwise specified herein or in the applicable specification sheet, all testing shall be conducted in accordance with MIL-DTL-81963.

4.2.1 Test Equipment and Inspection Facilities

The accuracy of test equipment and inspection facilities shall conform to MIL-DTL-81963.

4.2.2 Alternate Test Methods

Alternate test methods shall conform to MIL-DTL-81963.

4.3 Test Conditions

4.3.1 Standard Test Conditions

Unless otherwise specified, the standard test conditions shall be as specified in MIL-DTL-81963. Each test shall be carried out with the synchro in the applicable mounting fixture in accordance with MIL-DTL-81963. Mounting hardware shall conform to the requirements of Table 5.

4.3.2 Temperature, Stabilized Operating

The stabilized operating temperature of the synchro shall be as specified in MIL-DTL-81963, using the applicable secondary windings stipulated in Table 6 herein for the periodic dc resistance measurement.

4.3.3 Temperature, Stabilized Non-operating

The stabilized non-operating temperature of the synchro shall be as specified in MIL-DTL-81963 using the applicable secondary windings stipulated in Table 6 herein for the periodic dc resistance measurement.

4.3.4 Standard Test Voltage and Frequency

Unless otherwise specified, the test voltage and frequency of a true sine wave shall be as specified in Table 6. The voltage and frequency shall be maintained within a tolerance of ±1%. The total harmonic content shall be less than 1%.

4.4 Classification of Tests

The methods of sampling, inspection, and tests conducted on synchros shall be classified as follows:

a. Qualification (4.5)

b. First Article (4.6)

c. Quality Conformance (4.7)

4.5 Qualification Inspection

Qualification inspection shall be performed at a laboratory approved by the Naval Air Systems Command and shall be performed in accordance with MIL-DTL-81963 and Table 4 herein.

4.5.1 Qualification Sample

The qualification sample shall be as specified in MIL-DTL-81963.

4.5.2 Qualification Inspection Routine

The qualification inspection routine shall be performed in accordance with MIL-DTL-81963 and Table 4 herein.

4.5.3 Assessment of Qualification Approval Test Results

4.5.3.1 Qualification Sample Failure

Qualification sample failure shall be as specified in MIL-DTL-81963.

4.5.3.2 Degradation of Performance

The following relaxations may be permitted at the discretion of the qualifying activity in accordance with MIL-DTL-81963.

4.5.3.2.1 Acceptance Tests

All the specified performance characteristics must be attained.

4.5.3.2.2 Environmental Tests

As appropriate during or following each of the environmental tests, the following minor relaxations in specified requirements may be permitted. It should be noted that the relaxations are not cumulative; e.g., electrical error, if accepted at up to 1 minute of arc in addition to the specified maximum value following vibration, shall still not be more than 1 minute of arc in addition to the specified maximum value following low impact shock.

4.5.3.2.2.1 Variation of Brush Contact Resistance

A maximum variation of 1.5 Ω or 0.75% of rotor dc resistance specified in the specification sheet may be permitted. Following high impact shock, a maximum variation of 2.25 Ω or 1.125% of rotor dc resistance specified in the specification sheet is permissible.

4.5.3.2.2.2 Receiver Error

An increase of 6 minutes for sizes 11 and 15, 5 minutes for sizes 18 and 23, and 4 minutes for sizes 31 and 37, in addition to the maximum receiver error value specified in the specification sheet, is permissible. Following high impact shock, an increase to 1-1/2 times the maximum receiver error value specified in the specification sheet is permissible.

4.5.3.2.2.3 Electrical Error

An increase of 1 minute in addition to the maximum electrical error value specified in the specification sheet may be permitted. Following high impact shock, an increase to 1-1/2 times the maximum electrical error value specified in the specification sheet is permissible.

4.5.3.2.2.4 Mechanical Breakaway Torque

An increase to 2 times the maximum breakaway torque value specified in the specification sheet at standard test temperature may be permitted. Following high impact shock, an increase to 3 times the maximum breakaway torque value specified in the specification sheet at standard test temperature is permissible.

4.5.3.2.2.5 Shaft Radial Play

The maximum permissible radial play is 1-1/2 times the maximum value specified in the specification sheet. Following high impact shock, radial play not exceeding 2-1/4 times the maximum value specified in the specification sheet is permissible.

4.5.3.2.2.6 Shaft End Play

Irrespective of the limits specified in the specification sheet, a minimum end play value of 0.0001 inch is required. The maximum permissible end play is 1-2/3 times the maximum value specified in the specification sheet. Following high impact shock, end play not exceeding 2-1/2 times the maximum value specified in the specification sheet is permissible.

4.5.3.2.2.7 Residual Voltage

Following high impact shock, an increase of 50% in the maximum fundamental and total residual voltage values specified in the specification sheet is permissible.

4.5.3.2.2.8 Dielectric Withstanding Voltage

Following high impact shock, a winding leakage current increase to 1.5 mA peak maximum is permissible.

4.5.3.2.2.9 Insulation Resistance

Following high impact shock and having been immediately preceded by dielectric withstanding voltage, a reduction to 25 MΩ insulation resistance is permissible.

4.5.3.2.2.10 Major Failures During or Following Environmental Tests

Allowances having been made for the relaxations quoted in 4.5.3.2.2, failures experienced during or following environmental tests shall be dealt with as provided for in MIL-DTL-81963.

4.5.3.3 Qualification Sample Isolated Failure

In case of catastrophic failure, the procedures of MIL-DTL-81963 shall apply.

4.5.3.4 Qualification Approval by Analogy

Qualification approval by analogy shall be as specified in Figure 10 herein and MIL-DTL-81963.

4.5.3.4.1 Rules for Selection

Test samples shall be selected in accordance with 4.5.3.4.1.1 through 4.5.3.4.1.3 as depicted in Figure 10.

4.5.3.4.1.1 From a group of units submitted for qualification approval by analogy testing, the test samples shall be selected by successively dividing the group in the following sequence:

a. Frame Size

b. Voltage: 26 V or 115 V

c. Frequency: 60 Hz or 400 Hz

d. Synchro Function: Control or Torque

Having made the subdivision as above, the units shall then be grouped together with no more than three types comprising any one group.

4.5.3.4.1.2 From each group, four units shall be selected for the entire qualification approval test program. When there are only two types in a group, two of each shall be selected; but in the case of three types in a group, two shall be selected from the differential type and one each from the other two.

4.5.3.4.1.3 The sample group of units having been selected shall then be subjected to the qualification tests.

4.5.4 Disposition of Qualification Sample

Disposition of the qualification sample shall be as specified in MIL-DTL-81963.

4.5.5 Requalification

The frequency of qualification inspection in order to retain qualification approval shall be as specified in MIL-DTL-81963.

4.5.6 Changes

After samples have been submitted for qualification, no change shall be made in the materials, design, or manufacturing processes without prior approval of the qualifying activity.

4.5.7 Extensions of Qualification for Family of Parts

When qualification approval is granted for military part number M20708/X-01 (plus modification letter), such qualification approval shall be extended to all military part numbers listed for the same synchro type designation.

4.6 First Article Sample Inspection

When required by the contracting activity, first article shall be as specified in MIL-DTL-81963.

4.6.1 First Article Sample Failure

Action following first article sample failure shall be as specified in MIL-DTL-81963.

4.7 Conformance Inspection

Conformance inspection shall be as specified in MIL-DTL-81963 and Table 4 herein.

4.7.1 Conformance Inspection Sampling

Statistical sampling and inspection shall be as specified in MIL-DTL-81963. When the Accept on Zero requirement (as described in MIL-DTL-81963) specifies an action by the Government, it shall, at the option of the Government, be performed either by the Government or by the contractor under the supervision of the Government.

4.7.2 Conformance Inspection Routine

The minimum of inspection to be verified by the Government Inspector shall be the requirements of MIL-DTL-81963 and Table 4 herein. The Government Inspector may substitute 100% inspection for all or part of the sampling procedure.

4.7.3 Conformance Sample Failure

Action following conformance sample failure shall be as specified in MIL-DTL-81963.

4.8 Test Methods and Examinations

4.8.1 Visual and Mechanical Examination

The synchro shall be examined in accordance with MIL-DTL-81963 and shall meet the requirements of 3.6.1.

4.8.2 Variation of Brush Contact Resistance

Brush contact resistance test shall be conducted in accordance with MIL-DTL-81963 and shall be performed between terminals R1-R2 of transmitters, receivers, and control transmitters; between terminals R1-R2 and R1-R3 of differential transmitters and differential receivers; and between S1-S2 and S1-S3 of rotatable stator synchros, and shall meet the requirements of 3.6.2.

4.8.3 Shaft Radial and End Play

Shaft radial and end play shall be tested in accordance with MIL-DTL-81963 and shall meet the requirements of 3.6.3.

4.8.4 Shaft Runout

The synchro housing shall be rigidly mounted. A dial gauge shall be applied to the shaft within 0.125 inch of the bearing face and the shaft rotated. The difference between the extreme indicator readings shall be the shaft runout and shall meet the requirements of 3.6.4.

4.8.5 Mechanical Breakaway Torque

Mechanical breakaway torque test shall be conducted in accordance with MIL-DTL-81963 and shall meet the requirements of 3.6.5.

4.8.6 Torque Gradient Test

4.8.6.1 General

The synchro shall be energized in accordance with 4.3.4 until it reaches stabilized operating temperature (see 4.3.2). Torque shall be applied by weights suspended from a thread attached to the rim of a torque pulley rigidly mounted on the synchro shaft. The thread diameter shall be less than 0.01 times that of the pulley. A measuring device which will enable changes in angular position of the synchro shaft to be read within 15 minutes of arc shall be attached to the fixture. Predetermined weights of equal increments shall be applied, to cause deflections of approximately 2, 4, 6, 8, and 10 degrees in both clockwise and counterclockwise directions. The corresponding deflections shall be recorded and a torque-deflection curve plotted as the straight line best fitted to the observed points, and shall meet the requirements of 3.6.6.

4.8.6.1.1 Torque Transmitters and Receivers

4.8.6.1.1.1 Method 1

Torque transmitters and receivers shall be energized by applying voltage and frequency as specified in 4.3.4 to the R1-R2 terminals of the synchro. The stators of rotatable stator synchros shall be locked at synchro zero. Terminals S1 and S3 shall be connected together and the synchro tested in accordance with 4.8.6.1. The torque gradient shall be one-half the slope of the line expressed in ounce-inches per degree.

4.8.6.1.1.2 Method 2

Torque transmitters and receivers shall be electrically coupled to another transmitter of the same frame size and nominal impedance and energized by applying a voltage and frequency as specified in 4.3.4 to the R1 and R2 terminals of the synchros and tested in accordance with 4.8.6.1. The stators of rotatable synchros shall be locked at synchro zero. The torque gradient is the slope of the line expressed in ounce-inches per degree.

4.8.6.1.2 Torque Differential Transmitters and Receivers

4.8.6.1.2.1 Method 1

Torque differential transmitters and receivers shall be energized by applying the voltage and frequency as specified in 4.3.4 between terminal S1, which is connected to S3, and terminal S2. Terminals R1 and R3 shall be connected together and the synchro shall be tested in accordance with 4.8.6.1. The torque gradient shall be one-half the slope of the line expressed in ounce-inches per degree.

4.8.6.1.2.2 Method 2

Torque differential transmitters and receivers shall be energized by applying the voltage and frequency as specified in 4.3.4 between terminal S1, which is connected to S3, and terminal S2. The rotor terminals shall be connected to a torque transmitter's stator. The transmitter shall be the same frame size and frequency rating as the synchro under test and shall be locked on synchro zero and tested in accordance with 4.8.6.1. The torque gradient is the slope of the line expressed in ounce-inches per degree.

4.8.7 Dielectric Withstanding Voltage

The dielectric withstanding voltage test shall be conducted as specified in MIL-DTL-81963 and Table 7 herein and shall meet the requirements of 3.6.7.

4.8.8 Insulation Resistance

The insulation resistance between the application points stipulated in Table 7 shall be measured as specified in MIL-DTL-81963 and shall meet the requirements of 3.6.8 herein. For synchros with maximum operating voltages greater than 50 V rms, 500 V dc shall be applied between all application points. For synchros with maximum operating voltages less than 50 V rms, 100 V dc shall be applied between all application points.

4.8.9 Primary Current

Current drawn by the primary winding shall be measured with the secondary winding open-circuited, the synchro energized in accordance with 4.3.4, and as specified in MIL-DTL-81963. The current drawn shall meet the requirements of 3.6.9.

4.8.10 Primary Power

Power drawn by the primary winding shall be measured with the secondary winding open-circuited, the synchro energized in accordance with 4.3.4, and as specified in MIL-DTL-81963. The power consumed shall meet the requirements of 3.6.10.

4.8.11 Transformation Ratio Test

The synchro shall be energized and stabilized in accordance with 4.3.4 and 4.3.2, then the rotor turned in the positive direction from synchro zero until the first position of maximum coupling is reached. The secondary shall be connected to a measuring device which indicates or compares the rms voltage of the fundamental frequency and does not alter the open circuit secondary voltage by more than 0.1%. The transformation ratio shall meet the requirements of 3.6.11.

4.8.12 Phase Shift Test

Phase shift shall be measured with the synchro energized, stabilized, in accordance with 4.3.4 and 4.3.2 and rotor positioned as in 4.8.11 above. The secondary shall be connected to a measuring device which indicates or compares the phase shift to an accuracy of ±15 minutes and does not alter the open circuit voltages by more than 0.1%. The phase shift shall meet the requirements of 3.6.12.

4.8.13 Electrical Error Test

The synchro shall be energized as specified in 4.3.4 and stabilized as specified in 4.3.2. The electrical error shall be measured and recorded at every 5-degree position of the rotor and shall meet the requirements of 3.6.13. The total combined error of the test equipment during testing shall not exceed 30 seconds of arc. The stators of rotatable stator synchros shall be locked at synchro zero. The electrical error of both the rotor and stator shall be determined for differential transmitters and differential receivers. Examples of electrical error test setups for different types of units are shown in Figures 11 and 12.

4.8.14 Residual (null) Voltage Test

The synchro shall be energized as specified in Table 8 and the null readings made with the synchro at the electrical angles shown in Table 8. The voltage-measuring devices used in 4.8.14.1 and 4.8.14.2 shall indicate the average value of the voltage wave in terms of the rms value of an equivalent sine wave and shall have an input impedance of at least 500 000 Ω resistance shunted by a capacitance of 30 pF. The residual (null) voltage shall meet the requirements of 3.6.14.

4.8.14.1 Frequency Sensitive Voltmeter Method

A frequency sensitive voltmeter shall be used which has a fundamental frequency filter with characteristics for a change of ±1% in energizing frequency. The output voltage shall change no more than ±0.5% and be at least -30 db at half and twice rated frequency. The meter shall be properly compensated for the insertion loss of the filter. The synchro rotor shall be turned until a minimum voltage is obtained on the frequency sensitive voltmeter. The voltage is the fundamental component of the null voltage. Without disturbing the rotor position, the total null voltage shall be measured.

4.8.14.2 Phase-sensitive Voltmeter Method

The synchro rotor shall be turned until the in-phase component of the null voltage is zero as indicated on a phase-sensitive voltmeter. The quadrature voltage shall be read. This voltage is the fundamental component of the null voltage. Without disturbing this rotor position, the total null voltage shall be measured.

4.8.15 Receiver Error Test

4.8.15.1 General

The synchro under test shall be connected to a calibrated transmitter(s) of the same frame size and the same nominal impedance. The calibrated transmitter(s) and synchro under test shall then be rotated at 1 rpm. This calibrated transmitter(s) shall have met the acceptance requirements of this specification. The transmitter(s) and the synchro under test shall be energized in accordance with 4.3.4 and stabilized in accordance with 4.3.2. Stators of rotatable stator synchros shall be locked at synchro zero. If a low-pass filter is incorporated into the test equipment, it shall pass 10 Hz and below. The calibrated transmitter(s) and synchro under test shall be set at synchro zero with respect to the same reference. Receiver error shall be determined and recorded either continuously or at no greater than 5 degree intervals for both clockwise and counterclockwise compatible with the direction of rotation of both synchros. If the calibrated electrical error of the transmitter(s) exceeds 3 minutes, the receiver error shall be corrected. The receiver error shall meet the requirements of 3.6.15.

4.8.15.2 Receivers

4.8.15.2.1 Method 1

The shaft of the torque transmitter shall be mechanically coupled to the shaft of a control transformer. The stators of the receiver under test, the torque transmitter, and the control transformer shall be electrically connected and compatible to direction of rotation. A calibrated phase-sensitive nullmeter shall be placed across the output of the control transformer. The shaft of the control transformer shall be rotated and the receiver error interpreted from the calibrated phase-sensitive nullmeter when tested in accordance with 4.8.15.1.

4.8.15.2.2 Method 2

Stator terminals of the receiver and transmitter shall be connected. Both housings shall be locked rigidly together with respect to the same reference and the transmitter rotor secured at synchro zero. The synchros shall be tested in accordance with 4.8.15.1.

4.8.15.2.3 Method 3

Electrically connect a transmitter to an Angle Position Indicator (API) and record the digital output from the API with a data logger. While driving the transmitter at 1 rpm, record the readings at the rate of six per second for an interval of 70 seconds starting when the API reads 0.000 degrees. Repeat the process with the transmitter rotating in the opposite direction. A programmable synchro standard with the same nominal impedance as the synchro under test may be substituted for the transmitter, eliminating the need for the previous readings. Electrically connect the synchro under test to the transmitter and the API. Mechanically displace the shaft of the synchro under test 1 degree from the transmitter to determine the scale factor. The scale factor is a number, that when multiplied by the change in the API reading, equals 1 degree. Obtain another set of data by repeating the previous readings while the synchro under test is connected to the transmitter. The receiver error is the scale factor times the difference in the two sets of data.

4.8.15.3 Differentials

4.8.15.3.1 Method 1

The shaft of the torque transmitter shall be mechanically coupled to the shaft of a transformer. The stators of the torque transmitter and control transformer shall be electrically connected to the rotor of the differential receiver under test in such a manner as to maintain compatible direction of rotation. The stator of the differential receiver shall be connected to the stator of a second torque transmitter, the shaft of which is locked at synchro zero. A calibrated phase-sensitive nullmeter shall be placed across the output of the control transformer. The shaft of the control transformer shall be rotated and the receiver error interpreted with the calibrated phase-sensitive nullmeter when tested in accordance with 4.8.15.1.

4.8.15.3.2 Method 2

Terminals of the differential receiver rotor shall be connected to the stator of a transmitter, and the differential receiver stator terminals shall be connected to the stator of a second transmitter. Stator housings of the differential receiver and one transmitter shall be mechanically locked with respect to the same reference. Both transmitter shafts shall be locked at synchro zero to prevent rotation and the test shall be conducted in accordance with 4.8.15.1.

4.8.15.3.3 Method 3

This method is the same as 4.8.15.2.3 except the stator of the differential synchro is electrically connected to a second transmitter's stator with its shaft locked on synchro zero. The rotor is electrically connected to the driven transmitter's stator after the first set of readings are recorded and prior to testing the differential synchro.

4.8.16 Spinning Test

The applicable test dial used for mechanical breakaway torque as specified in MIL-DTL-81963 shall be mounted rigidly on the shaft of the receiver or differential receiver. The synchro receiver shall be connected to the appropriate terminals of a torque transmitter, or in the case of a differential receiver, to two transmitters of a size 37 for 115-V synchros or a size 11 for 26-V synchros. The rotor(s) of the transmitter(s) shall be locked in the synchro zero position. The rotor of the synchro under test shall be displaced 177 degrees ± 2 degrees from synchro zero and the synchros energized with 120% of standard test voltage at rated frequency. This procedure shall be performed five times for a clockwise displacement and five times for a counterclockwise displacement and shall meet the requirements of 3.6.16.

4.8.17 Synchronizing Time Test

Terminals of the synchro under test shall be connected to the appropriate terminals of a torque transmitter(s) of the same size and the same nominal impedance as the synchro under test. The rotor(s) of the transmitter(s) shall be locked at synchro zero. The applicable test dial used for mechanical breakaway torque as specified in MIL-DTL-81963 shall be rigidly mounted on the shaft of the synchro under test. The synchro under test shall be displaced 30 degrees ± 2 degrees clockwise, energized in accordance with 4.3.4, and the time required to return to synchro zero and remain within 1 degree of zero shall be measured. The synchronizing time shall be the average of three successive tests. This test shall be repeated at a displacement of 30 degrees ± 2 degrees counterclockwise. The above test shall be repeated at displacements of 177 degrees ± 2 degrees clockwise and counterclockwise. The synchronizing time for any test position shall meet the requirements of 3.6.17.

4.8.18 Security of Terminals and Wire Leads

The security of each screw type or solder pin type of terminal or of each wire lead shall be tested in accordance with MIL-DTL-81963 and shall meet the requirements of 3.6.18.

4.8.19 Impedance

The impedance of the synchro windings shall be measured in accordance with MIL-DTL-81963 when energized in accordance with 4.3.4 and Table 9 herein. Impedance shall be determined at synchro zero and shall meet the requirements of 3.6.19.

4.8.20 Temperature Rise

Temperature rise shall be conducted in accordance with MIL-DTL-81963 and shall meet the requirements of 3.6.20, using secondary windings for dc resistance measurements. Windings shall be energized as specified in 4.3.4.

4.8.21 Variation of Voltage and Frequency

The synchro shall be energized and stabilized in accordance with 4.3.2 and 4.3.4. The voltage shall then be adjusted to 110% of voltage specified in Table 6 and the frequency adjusted to 95% of the value specified in Table 6. The power drawn from the energizing source shall meet the requirements of 3.6.21.

4.8.22 Audible Noise, Structureborne

Structureborne noise test shall be conducted in accordance with MIL-DTL-81963, energized in accordance with 4.3.4, and shall meet the requirements of 3.6.22, when required by the applicable specification sheet.

4.8.23 Electromagnetic Interference

Electromagnetic interference test shall be conducted in accordance with MIL-DTL-81963. The rotor of the synchro shall be rotated at 1150 ±50 rpm and shall be energized as indicated in Table 10. The synchro shall meet the requirements of 3.6.23, when required by the applicable specification sheet.

4.8.24 Synchro Zero Marking

The applicable synchro windings shall be connected as shown in Figures 1, 2, and 3, phased in accordance with 3.4.3, and the rotor turned until the nullmeter minimum reading is obtained. The relative position of the synchro zero index marked on the housing and the index marked on the shaft shall be in accordance with 3.5.2.

4.9 Environmental

4.9.1 Vibration

All synchros shall be tested in accordance with MIL-DTL-81963. During the test, the synchros shall be energized in accordance with Table 10 with their rotor shafts free to rotate while mechanically loaded. Immediately after the test, each synchro shall be examined for loose or damaged parts and shall meet the requirements of 3.7.1.

4.9.2 Shock

4.9.2.1 Shock, Specified Pulse

All synchros shall be tested in accordance with MIL-DTL-81963, energized in accordance with Figures 13, 14, or 15 with their rotor shafts free to rotate while mechanically loaded and shall meet the requirements of 3.7.2.1.

4.9.2.2 Shock, High Impact

All synchros shall be tested in accordance with MIL-DTL-81963, energized in accordance with Figures 13, 14, or 15 with their rotor shafts free to rotate while mechanically loaded and shall meet the requirements of 3.7.2.2.

4.9.3 Altitude

4.9.3.1 Altitude Low Temperature

Synchros shall be tested in accordance with MIL-DTL-81963, energized in accordance with 4.3.4 and shall meet the requirements of 3.7.3.1.

4.9.3.2 Altitude High Temperature

Synchros shall be tested in accordance with MIL-DTL-81963, energized in accordance with 4.3.4 and shall meet the requirements of 3.7.3.2.

4.9.4 Endurance

Synchros, except rotatable stator units, shall be tested in accordance with MIL-DTL-81963, energized in accordance with 4.3.4, and the rotor turned at 1150 rpm ± 50 rpm. Synchros of the rotatable stator type shall be continuously operated for 2000 hours, energized in accordance with 4.3.4, the housing held stationary, and the rotatable stator rotated at 200 rpm ± 10 rpm. Synchros shall meet the requirements of 3.7.4.

4.9.5 Ambient Temperature Test

The temperature extremes required under 4.9.5.1 and 4.9.5.2 are tests for storage extremes and are required to be accomplished once per synchro. Synchros may be conditioned at the operational temperatures as often as necessary to perform the required test. Upon completion of the temperature test, the synchro shall be removed from the test chamber and allowed to remain at the standard test conditions of 4.3.1 for at least 4 hours before undergoing further tests.

4.9.5.1 Ambient Low Temperature

Synchros shall be subjected to the ambient low temperature tests in accordance with MIL-DTL-81963 and 4.9.5 herein. The synchros shall be energized in accordance with 4.3.4 and shall meet the requirements of 3.7.5.1.

4.9.5.2 Ambient High Temperature

Synchros shall be subjected to ambient high temperature tests of 125 °C ± 2 °C, unless otherwise specified in the applicable specification sheet, in accordance with MIL-DTL-81963 and 4.9.5 herein. The synchros shall be energized in accordance with 4.3.4 and shall meet the requirements of 3.7.5.2.

4.9.6 Moisture Resistance

Synchros shall be subjected to the moisture resistance test in accordance with MIL-DTL-81963, energized in accordance with 4.3.4, and shall meet the requirements of 3.7.6 herein.

4.9.7 Explosion Resistance

The synchro shall be tested in accordance with MIL-STD-202, Method 109, while being vibrated according to 4.9.1 and energized as specified in Table 10. The synchro shall meet the requirements of 3.7.7, when required by the applicable specification sheet. For additional information pertaining to explosion resistance, see MIL-DTL-81963.

4.9.8 Salt Atmosphere

Synchros shall be subjected to the salt atmosphere test in accordance with MIL-DTL-81963 and shall meet the requirements of 3.7.8, when required by the applicable specification sheet.

5. PACKAGING

5.1 Packaging

For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the Military Service's System Commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

The requirements for packaging shall be in accordance with MIL-DTL-81963.

6. NOTES

6.1 Intended Use

Synchros covered by this specification are intended for use in military systems for fire control of guns, radar, navigation, guided missiles, and other precision applications.

6.2 Acquisition Requirements

Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Title, number, and date of the specification sheet, and the military part number (see 3.1).

c. Levels of preservation and packing required (see 5.1).

d. Whether first article inspection is required (see 3.3).

6.3 First Article Inspection

Information pertaining to first article inspection of synchros shall be obtained as specified in MIL-DTL-81963.

6.4 Qualification

With respect to products requiring qualification, awards will be made in accordance with MIL-DTL-81963 and only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL-AS20708, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for this Qualified Products List is the Naval Air Systems Command (Attention: QPD/QPL Team, Naval Air Warfare Center Aircraft Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100, Tel: 732-323-2740, FAX 1-732-323-7228, http://quicksearch.dla.mil).

6.5 Definitions of Synchro and Synchro System Types

6.5.1 Synchro

A synchro is an electromechanical analog converter which, through electromagnetic means, gives an electrical output that is a function of its rotor position or positions its rotor to an angle that is a function of the electrical input.

6.5.1.1 Synchro Transmitter

A synchro transmitter converts a mechanical input (rotor position) into an electrical output.

6.5.1.2 Synchro Receiver

A synchro receiver converts an electrical input into a rotor position as a mechanical output.

6.5.1.3 Synchro Differential Transmitter

A synchro differential transmitter gives an electrical output which is a function of two inputs - its electrical input and its mechanical input (rotor position).

6.5.1.4 Synchro Differential Receiver

A synchro differential receiver gives a mechanical output (rotor position) which is a function of two electrical inputs - its primary input and its secondary input.

6.5.1.5 Control Transformer

A control transformer, in conjunction with an amplifier and servomotor, converts an electrical input into a rotor position in high torque applications. The electrical output of the control transformer is amplified and applied to a servomotor which drives the load and the transformer to the null position.

6.5.2 Synchro System

A synchro system is a circuit containing one or more synchros that operate on angular information and convey this information over a distance.

6.5.3 Torque Synchro System

A torque synchro system is a system in which the transmitted signal does usable work.

6.5.4 Control Synchro System

A control synchro system is a system in which the transmitted signal controls a source of power which does work.

6.6 Definitions and Conventions

6.6.1 Rotor Angular Displacement

6.6.1.1 Rotor Position

The rotor position of any synchro is an angular mechanical rotor displacement from the synchro zero position, measured in the positive direction.

6.6.1.2 Rotor Angle

The rotor angle of a practical synchro is the angular mechanical rotor displacement from the synchro zero position, measured in the positive direction, at which the synchro's output voltages exactly correspond to the output voltages of an ideal synchro set at any specific rotor position.

6.6.2 Electrical Error

The electrical error at a given rotor position is the electrical angle minus the rotor position or the rotor position minus the rotor angle (see Figure 16).

6.6.3 Receiver Error

Receiver error is the difference in the shaft displacement of the receiver under test to the corresponding shaft position of a torque transmitter of equal size.

6.6.4 Synchronizing Time

Synchronizing time is the time required for the rotor of a synchro receiver or differential receiver to approach and stay within 1.0 degree of rest when energized.

6.6.5 Impedance

6.6.5.1 Rotor Open-circuit Impedance

The rotor open-circuit impedance of a synchro is:

Zro = The impedance of the rotor with the stator terminals open.

6.6.5.2 Stator Open-circuit Impedance

The stator open-circuit impedance of a synchro is:

Zso = The stator impedance with the rotor terminals open.

6.6.5.3 Rotor Short-circuit Impedance

The rotor short-circuit impedance of a synchro is:

Zrs = The impedance of the rotor with the stator terminals shorted.

6.6.5.4 Stator Short-circuit Impedance

The stator short-circuit impedance of a synchro is:

Zss = The impedance of the stator with the rotor terminals shorted.

6.6.6 Primary and Secondary Windings

For transmitter and receiver synchros, the rotor is the primary and the stator is the secondary. For control transformers and differential synchros, the stator is the primary and the rotor is the secondary.

6.6.7 Rated Voltage

The rated voltage of synchros is the line voltage of the synchro system power supply; i.e., 115 V or 26 V.

6.6.8 In-time-phase Secondary Voltages

The in-time-phase secondary voltage is the time phase fundamental component of the secondary voltage at the first position of maximum coupling when the synchro rotor is turned in the positive direction from synchro zero.

6.6.9 Transformation Ratio

The transformation ratio is the ratio of the fundamental frequency component of the no-load secondary voltage at maximum coupling to the voltage applied to the primary.

6.6.10 Phase Shift

Phase shift is the difference between the time phase of the fundamental component of the primary voltage and the time phase of the secondary voltage of the synchro at the first position of maximum coupling in the positive direction from synchro zero.

6.6.11 Shaft Radial and End Play

The radial play of a synchro rotor is the shaft displacement perpendicular to the shaft axis due to the reversal of a force applied perpendicular to the shaft axis. The end play of a synchro rotor is the axial shaft displacement due to the reversal of an axial force (see 3.6.3).

6.6.12 Mechanical Breakaway Torque

Mechanical breakaway torque is the torque required to turn the rotor of a synchro from rest when unenergized.

6.6.13 Torque Gradient

Torque gradient is the initial rate of change of torque with angular displacement of the rotor from a position where the torque is zero, when the synchro is energized from a standard torque transmitter of the same frame size and rating. The torque gradient is normally given as the mean value obtained in the range of ±10 degrees from the zero torque position.

6.6.14 Residual (Null) Voltage

Residual voltage in a synchro is the actual voltage present at the secondary terminals at that position at which the theoretical secondary voltage is zero. This voltage consists of the quadrature component of the energizing frequency and a component which is made up of harmonics of the energizing frequency. Fundamental residual voltage is the quadrature component of the energizing frequency; total residual voltage is the fundamental residual voltage and harmonics.

6.6.15 Time Phase

The time phase at a point in a synchro system is the phase of the voltage at that point with respect to the phase of the energizing voltage of the system.

6.6.16 Temperature Rise

Temperature rise is the increase of the internal temperature of a synchro above the ambient temperature due to the dissipation of the energizing power.

6.6.17 Units

Unless otherwise specified, units of measurement are as follows:

a. Angles - degrees, minutes

b. Potential - volts, rms

c. Impedance - ohms

d. Current - amperes, rms

e. Temperature - degrees, centigrade

f. Time Phase - degrees

g. Torque - ounce-inches

h. Time - seconds

6.7 Mounting Hardware for Design Applications

Information on mounting hardware and mounting methods for design applications may be found in MIL-HDBK-225 (see Table 5). Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-9495, http://quicksearch.dla.mil

6.8 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

6.9 International Standardization Agreement

Certain provisions of this specification are the subject of international standardization agreements reached by the NATO Study Group on Analogue and Digital Servocomponents (AC/301(SGI)(STG/1)). When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental standardization offices, if required.

6.10 Tin Whisker Growth

The use of alloys with tin content greater than 97%, by mass, may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacture and can develop under typical operating conditions, on products that use such materials. Conformal coatings applied over top of a whisker-prone surface will not prevent the formation of tin whiskers. Alloys of 3% lead, by mass, have shown to inhibit the growth of tin whiskers. For additional information on this matter, refer to ASTM B545 (Standard Specification for Electrodeposited Coatings of Tin) (see 3.5.4).

6.11 Environmentally Preferable Material

Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website at http://www.epa.gov/osw/hazard/wastemin/priority.htm. Included in the list of 31 priority chemicals are cadmium, lead, and mercury. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein (see 3).

PREPARED BY SAE SUBCOMMITTEE AE-7A, GENERATORS/CONTROLS/MAGNETIC DEVICES OF COMMITTEE AE-7, AEROSPACE ELECTRICAL POWER AND EQUIPMENT

TABLE 1 - NOMENCLATURE

Synchro Transmitter	15	CX	4	D	M20708/14-01D
	(Type Designation)				
Item Name	Size	Function	Supply Frequency	Design Modification	Military Part Number
(1.2.1.1)	(1.2.1.2)	(1.2.1.3)	(1.2.1.4)	(1.2.1.5)	(1.2.1.6)

TABLE 2 - TERMINATION IDENTIFICATION MARKING

Terminal No.	Wire Lead Color	NEMA Color Code (see 3.5.1.1) 1/	Winding
R1	Red, White tracer	HP 3-ETWBBB2/9	Rotor 1
R2	Black, White tracer	HP 3-ETWBBB0/9	Rotor 2
R3 (if used)	Yellow, White tracer	HP 3-ETWBBB4/9	Rotor 3
S1	Blue	HP 3-ETWBBB6	Stator 1
S2	Black	HP 3-ETWBBB0	Stator 2
S3	Yellow	HP 3-ETWBBB4	Stator 3

1/ For synchro frame sizes 05, wire leads shall conform to NEMA HP 3-ETWBBB. For synchro frame sizes 08, 11, 15, wire leads shall conform to NEMA HP 3-EWBCB.

TABLE 3 - STANDARD DIMENSIONS FOR SYNCHROS

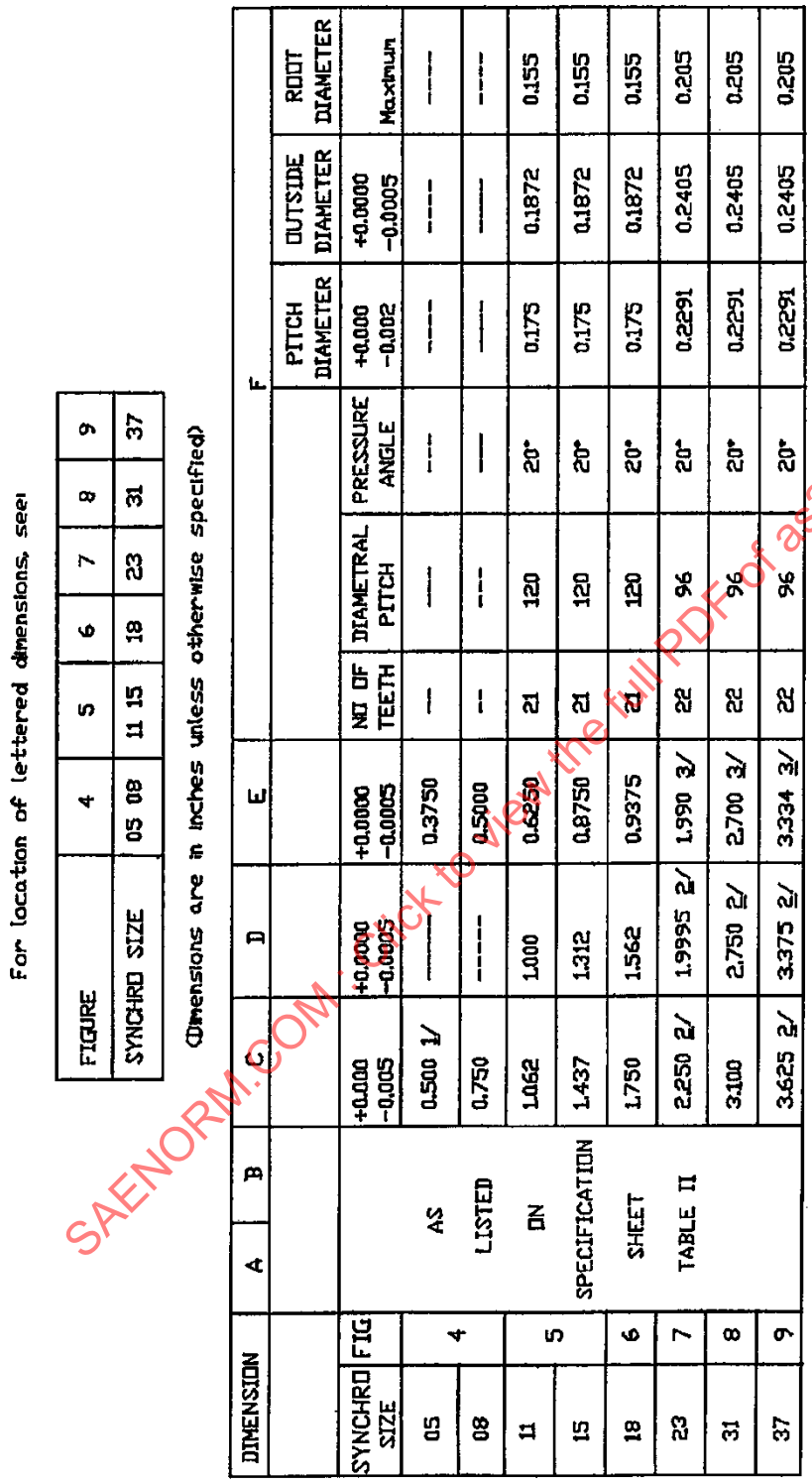


FIGURE	4	5	6	7	8	9
SYNCHRO SIZE	05 08	11 15	18	23	31	37

For location of lettered dimensions, see

Dimensions are in inches unless otherwise specified

DIMENSION		A	B	C	D	E	F				
								PITCH DIAMETER	OUTSIDE DIAMETER	ROOT DIAMETER
SYNCHRO SIZE	FIG			+0.000 -0.005	+0.0000 -0.0005	+0.0000 -0.0005	NO OF TEETH	DIAMETRAL PITCH	PRESSURE ANGLE	+0.000 -0.002	+0.0000 -0.0005	Maximum
05	4	AS LISTED IN SPECIFICATION SHEET TABLE II		0.500 1/	------	0.3750	--	----	---	-----	-----	-----
08				0.750	------	0.5000	--	---	---	-----	-----	-----
11	5			1.062	1.000	0.6250	21	120	20°	0.175	0.1872	0.155
15				1.437	1.312	0.8750	21	120	20°	0.175	0.1872	0.155
18	6			1.750	1.562	0.9375	21	120	20°	0.175	0.1872	0.155
23	7			2.250 2/	1.9995 2/	1.990 3/	22	96	20°	0.2291	0.2405	0.205
31	8			3.100	2.750 2/	2.700 3/	22	96	20°	0.2291	0.2405	0.205
37	9			3.625 2/	3.375 2/	3.334 3/	22	96	20°	0.2291	0.2405	0.205

NOTES: 1/ Tolerance +0.000 -0.003

2/ Tolerance +0.000 -0.001

3/ Tolerance +0.000 -0.005

4/ Dimension “A” does not apply when a threaded retainer is used in lieu of a snap ring retainer.

TABLE 3 - STANDARD DIMENSIONS FOR SYNCHROS (CONTINUED)

(Dimensions are in inches unless otherwise specified)

DIMENSION		G	H	I	J	K	L	M	N'	N	N'
SYNCHRO SIZE	FIG		±0.005	±0.005	±0.005	±0.005	±0.005	Min	Min	Min	Min
05	4	AS LISTED ON SPECIFICATION SHEET TABLE II	0.040 1/	-----	0.040 1/	0.040 1/	0.437 1/	-----	-----	-----	-----
08			0.040	-----	0.062	0.062	0.687	-----	-----	-----	-----
11	5		0.062	0.062	0.093	0.062	0.975	0.300	0.180	0.146	0.250
15			0.040	0.132	0.093	0.078	1.312	0.308	0.190	0.166	0.253
18	6		0.040	0.132	0.093	0.078	1.625	0.308	0.190	0.166	0.253
23	7		0.420	0.170	0.250	0.203	-----	0.333	0.280	0.156	0.382
31	8		0.990	0.375	0.250	0.250	-----	0.336	0.300	0.185	0.377
37	9		1.030	0.375	0.250	-----	3.390 1/	0.336	0.300	0.185	0.377

NOTE: 1/ Tolerance +0.000 -0.003

TABLE 3 - STANDARD DIMENSIONS FOR SYNCHROS (CONTINUED)

(Dimensions are in inches unless otherwise specified)

DIMENSION		Q	P	Q	R	S	T	U	V
SYNCHRO SIZE	FIG	±0.003	±0.003	±0.003	±0.005	Maximum	+0.000 −0.005		Minimum
05	4	-----	-----	-----	-----	-----	-----	AS LISTED ON SPECIFICATION SHEET TABLE II	-----
08		-----	-----	-----	-----	-----	-----		0.245
11	5	0.812	0.062	0.125	0.812	0.020	0.506		0.285
15		1.100	0.062	0.125	1.075	0.060	0.665		0.450
18	6	1.250	0.062	0.125	1.075	0.060	0.810		0.545
23	7	-----	0.062	0.125	1.437	-----	0.064 1/		-----
31	8	-----	0.062	0.125	2.322	-----	0.064 1/		-----
37	9	-----	-----	-----	2.322	-----	-----		-----

NOTE: 1/ Tolerance ±0.010

2/ Dimension “V” does not apply when a threaded retainer is used in liew of a snap ring retainer.

TABLE 3 - STANDARD DIMENSIONS FOR SYNCHROS (CONTINUED)

(Dimensions are in inches unless otherwise specified)

DIMENSION		W	X	Y	Z	CC	DD	EE
SYNCHRO SIZE	FIG	±0.005	±0.010	±0.005	Maximum	Maximum	+0.000 −0.001	Maximum
05	4	-----	-----	-----	-----	-----	-----	-----
08		-----	0.023	-----	0.748	0.750 2/	-----	-----
11	5	-----	0.069	-----	1.062	-----	-----	-----
15		-----	0.117	-----	1.437	-----	-----	-----
18	6	-----	0.117	-----	1.437	1.750	-----	-----
23	7	0.595	0.463 1/	-----	1.990	-----	1.9995	1.990
31	8	-----	1.020 1/	-----	2.700	-----	2.750	2.700
37	9	1.625	1.220 1/	1.812	2.700	-----	-----	3.334 3/

NOTE: 1/ Tolerance ±0.005
2/ Tolerance +0.000 −0.003
3/ Tolerance +0.000 −0.005

TABLE 4 - QUALIFICATION AND QUALITY CONFORMANCE INSPECTION

Test No.	Require-ment	Test	Test method or examination	Type					Inspection	
				CT, CTB CDX, CDXB CX, CXB	TX	TDX	TRX	TR TRB TDR	Qualifi-cation Sample Number	Quality Confor-mance
1	3.6.2	4.8.2	Variation of brush contact resistance 1/	X	X	X	X	X	1,2,3,4	X
2	3.6.1	4.8.1	Visual and mechanical inspection 2/	X	X	X	X	X	1,2,3,4	X
3	3.6.3	4.8.3	Shaft radial & end play 1/	X	X	X	X	X	1,2,3,4	X
4	3.6.4	4.8.4	Shaft runout	X	X	X	X	X	1,2,3,4	X
5	3.6.5	4.8.5	Mechanical breakaway torque	X	X	X	-	-	1,2,3,4	X
6	3.6.6	4.8.6	Torque gradient	-	X	X	X	X	1,2,3,4	X
7	3.6.7	4.8.7	Dielectric withstanding voltage	X	X	X	X	X	1,2,3,4	X
8	3.6.8	4.8.8	Insulation resistance	X	X	X	X	X	1,2,3,4	X
9	3.6.9	4.8.9	Primary current	X	X	X	X	X	1,2,3,4	X
10	3.6.10	4.8.10	Primary power	X	X	X	X	X	1,2,3,4	X
11	3.6.11	4.8.11	Transformation ratio	X	X	X	X	X	1,2,3,4	X
12	3.6.12	4.8.12	Phase shift	X	X	X	X	X	1,2,3,4	X
13	3.5.2	4.8.24	Zero marking	X	X	X	X	X	1,2,3,4	X

TABLE 4 - QUALIFICATION AND QUALITY CONFORMANCE INSPECTION (CONTINUED)

Test No.	Require-ment	Test	Test method or examination	Type					Inspection	
				CT, CTB CDX, CDXB CX, CXB	TX	TDX	TRX	TR TRB TDR	Qualifi-cation Sample Number	Quality Confor-mance
14	3.6.13	4.8.13	Electrical error	X	X	X	X	X	1,2,3,4	X
15	3.6.14	4.8.14	Residual (null) voltage	X	X	-	X	-	1,2,3,4	X
16	3.6.15	4.8.15	Receiver error	-	-	-	X	X	1,2,3,4	X
17	3.6.16	4.8.16	Spinning	-	-	-	X	X	1,2,3,4	X
18	3.6.17	4.8.17	Synchronizing time	-	-	-	X	X	1,2,3,4	X
19	3.6.19	4.8.19	Impedance	X	X	X	X	X	1,2,3,4	-
20	3.6.20	4.8.20	Temperature rise	X	X	X	X	X	1,2,3,4	-
21	3.6.21	4.8.21	Variation of voltage and frequency	-	X	X	X	X	1,2,3,4	-
22	3.6.22	4.8.22	Audible noise, structureborne 3/	X	X	X	X	X	1,2,3,4	-
23	3.6.23	4.8.23	Electromagnetic interference 3/	X	X	X	X	X	1,2,3,4	-
24	3.7.1	4.9.1	Vibration, followed by tests nos. 1, 2, 3, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	1,2,3,4	-
25	3.7.2.1	4.9.2.1	Shock, low impact followed by test nos. 1, 2, 3, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	1,2,3,4	-

TABLE 4 - QUALIFICATION AND QUALITY CONFORMANCE INSPECTION (CONTINUED)

Test No.	Require-ment	Test	Test method or examination	Type					Inspection	
				CT, CTB CDX, CDXB CX, CXB	TX	TDX	TRX	TR TRB TDR	Qualifi-cation Sample Number	Quality Confor-mance
26	3.7.3.1	4.9.3.1	Altitude, low temperature, perform test nos. 1, 2, and 8	X	X	X	X	X	1,2	-
27	3.7.3.2	4.9.3.2	Altitude, high temperature, perform test nos. 1, 2, and 8	X	X	X	X	X	1,2	-
28	3.7.4	4.9.4	Endurance, followed by test nos. 1, 2, 3, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	1,2	-
29	3.7.5.1	4.9.5.1	Ambient low temperature, perform test nos. 1, 2, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	3,4	-
30	3.7.5.2	4.9.5.2	Ambient high temperature, perform test nos. 1, 2, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	3,4	-
31	3.7.6	4.9.6	Moisture resistance followed by test nos. 1, 2, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	3,4	-
32	3.7.2.2	4.9.2.2	Shock, high impact, followed by test nos. 1, 2, 3, 5, 7, 8, 14, 15, 16, and 18	X	X	X	X	X	1,2,3,4	-

TABLE 4 - QUALIFICATION AND QUALITY CONFORMANCE INSPECTION (CONTINUED)

Test No.	Require-ment	Test	Test method or examination	Type					Inspection	
				CT, CTB CDX, CDXB CX, CXB	TX	TDX	TRX	TR TRB TDR	Qualifi-cation Sample Number	Quality Confor-mance
33	3.7.7	4.9.7	Explosion resistance 3/	X	X	X	X	X	1,2	-
34	3.7.8	4.9.8	Salt atmosphere 3/	X	X	X	X	X	1,2	-
35	3.6.18	4.8.18	Security of terminals or wire lead stress	X	X	X	X	X	1,2,3,4	-

1/ If mechanical adjustments are performed during the quality conformance tests, then all the Quality Conformance tests of Table IV shall be repeated following the adjustments.

2/ When required by Test nos. 24 through 32, only visual examination need be performed.

3/ Test shall be performed only when required by the specification sheet.

TABLE 5 - HARDWARE FOR MOUNTING SYNCHROS TO TEST FIXTURES 1/

Hardware	Number Required	Military Standard 3/	Synchro Size
Machine Screw	5 EA 2/	MS35276-203 MS35275-213 MS35275-227	11 15, 18, 23 31, 37
Lock Washer	5 EA 2/	MS35338-134 MS35338-135 MS35338-136	11 15, 18, 23 31, 37
Drive Washer	1 EA	MS17186-6 MS17186-8	11, 15, 18, 23, 31, 37
Nut	1 EA	MS17187-2 MS17187-3	11, 15, 18, 23, 31, 37

1/ For information only, see MS17183, Clamp Assembly (Synchro) For test purposes only. See 6.7 for mounting hardware and methods for design applications. Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-9495, http://quicksearch.dla.mil

2/ Differential transmitters (CDX, TDX and CDXB) require 6 each machine screws and lock washers instead of the 5 each required in all other types of synchros.

3/ MS35275, MS35276, and MS35338 are replaced-by NAS35275, NAS35276, and NAS35338 respectively, for which the part numbers are identical. The part numbers have not been changed.

TABLE 6 - STANDARD TEST ENERGIZING CONNECTIONS

Synchro Type	Primary		Voltage in Approximate Time Phase 1/ 2/	Secondary Terminals
	Volts 3/	Terminals 4/	Secondary and Primary	
Transmitter & Receiver	115 or 26 5/	R1-R2	E(S1S2) and E(R2R1) E(S3S2) and E(R2R1)	S1-S3
Differential Transmitter & Receiver	78 or 10.2 5/	S2-S1S3	E(R3R2) and E(S3S2) E(R1R2) and E(S1S2)	R1-R3
Control Transformer	78 or 10.2 5/	S2-S1S3	E(R1R2) and E(S2S1) 6/ E(R1R2) and E(S2S3) 6/	R1-R2

1/ E(S1S2) is the voltage between terminals S1 and S2. Other voltages are similarly defined.
2/ The sequence as indicated in parentheses designates the sense of voltage vector.
3/ Frequency of 60 or 400 Hz, as applicable.
4/ S1S3 indicates that terminals S1 and S3 are connected together.
5/ Applies to 26-V Synchros.
6/ For small counterclockwise deflections from synchro zero.

TABLE 7 - DIELECTRIC WITHSTANDING VOLTAGES AND APPLICATION POINTS

Maximum Rated Voltage, rms	Initial Test Voltages, Rms (50 or 60 Hz)	Subsequent Test Voltages Rms (50 or 60 Hz)
	Each winding to housing and primary to secondary windings	Each winding to housing and primary to secondary windings
Up to 50	242 to 250	194 to 200
51 to 100	485 to 500	388 to 400
101 to 200	870 to 900	696 to 720

TABLE 8 - CONNECTIONS, ENERGIZING VOLTAGE AND ANGULAR DISPLACEMENTS FOR RESIDUAL NULL VOLTAGE TEST

Test Unit	Primary Supply Test Voltage			Residual (Null) Voltage Reading	
	Across Terminals 1/	115-V Synchros	26-V Synchros	Across Terminals	At Electrical Angles
CX, TX, TR	R1-R2	115.0	26.0	S1-S3	0° and 180°
				S3-S2	60° and 240°
				S2-S1	120° and 300°
CDX, TDX, TDR	S2-S1S3	78.0	10.2	R1-R3	0° and 180°
				R2-R1	60° and 240°
				R3-R2	120° and 300°
CDX, TDX, TDR	S3-S1S2	78.0	10.2	R2-R1	0° and 180°
				R3-R2	60° and 240°
				R1-R3	120° and 300°
CDX, TDX, TDR	S1-S2S3	78.0	10.2	R3-R2	0° and 180°
				R1-R3	60° and 240°
				R2-R1	120° and 300°
CT	S2-S1S3	78.0	10.2	R1-R2	0° and 180°
	S1-S2S3	78.0	10.2	R1-R2	60° and 240°
	S3-S1S2	78.0	10.2	R1-R2	120° and 300°

1/ S1S3 indicates that terminals S1 and S3 are connected together. Other connections are similarly defined.

TABLE 9 - IMPEDANCE DESIGNATIONS

Impedance	Type of Synchro Under Test	Terminals for Impedance Measurements 1/	Voltage Across Synchro Terminals		Additional Connections
			115 V Synchros	26 V Synchros	
Rotor, Open Circuit Impedance Zro	CX, TX, TR, TRX CT CDX, TDX, TDR	R1-R2 R1-R2 R2-R1R3	115 57.3 78	26 22.5 10.2	- - -
Stator, Open Circuit Impedance Zso	All types	S2-S1S3	78	10.2	-
Rotor, Short Circuit Impedance Zrs	CX, TX, CT, TR, TRX CDX, TDX, TDR	R1-R2 R2-R1R3	2/ 2/	2/ 2/	S1S2S3 S1S2S3
Stator, Short Circuit Impedance Zss	CX, CT, TX, TR, TRX CDX, TDX, TDR	S2-S1S3 S2-S1S3	3/ 3/	3/ 3/	R1R2 R1R2R3

1/ R1R3 indicates that terminals R1 and R3 are connected together. Other connections are similarly defined.

2/ The voltage necessary to induce a current within ±3% of current in Zro measurement.

3/ The voltage necessary to induce a current within ±3% of current in Zso measurement.

TABLE 10 - CONNECTIONS AND VOLTAGES FOR ELECTROMAGNETIC INTERFERENCE, VIBRATION, ENDURANCE AND EXPLOSION TESTS

Type	Terminals 1/	Voltage	
		115 V Synchros	26 V Synchros
Transmitters and receivers	R1-R2	115% ± 5%	26.0% ± 5%
Differential receivers and differential transmitters	R2-R1R3	78% ± 5%	10.2% ± 5%
Control transformers	R1-R2	57% ± 5%	22.2% ± 5%

1/ R1R3 indicates that terminals R1 and R3 are connected together.

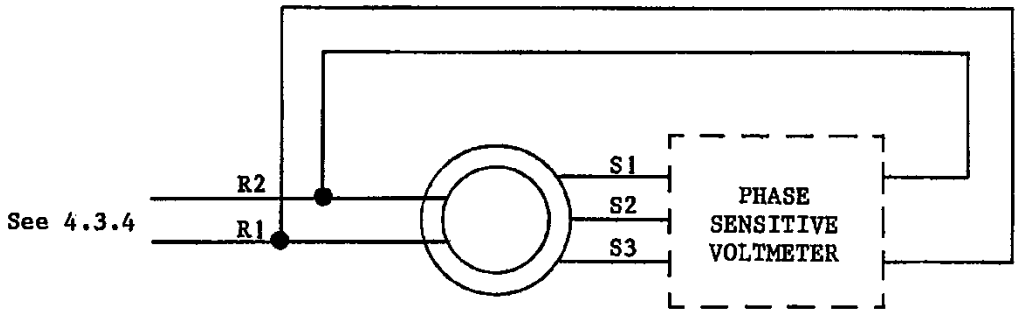


FIGURE 1 - DIAGRAM FOR DETERMINING SYNCHRO ZERO POSITION OF TRANSMITTERS AND RECEIVERS

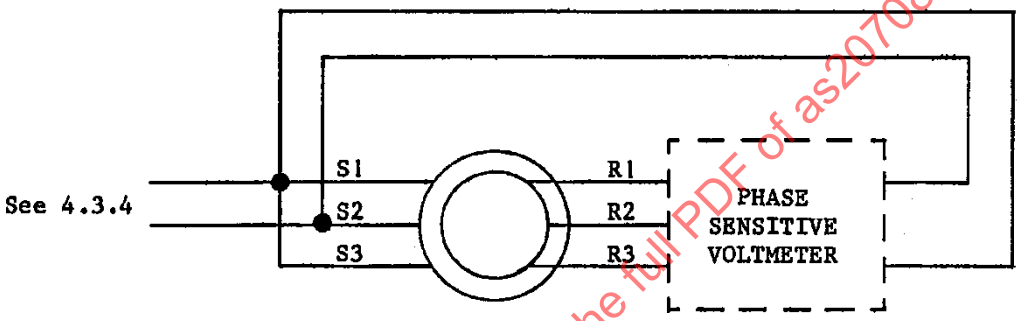


FIGURE 2 - DIAGRAM FOR DETERMINING SYNCHRO ZERO POSITION OF DIFFERENTIAL TRANSMITTERS AND DIFFERENTIAL RECEIVERS

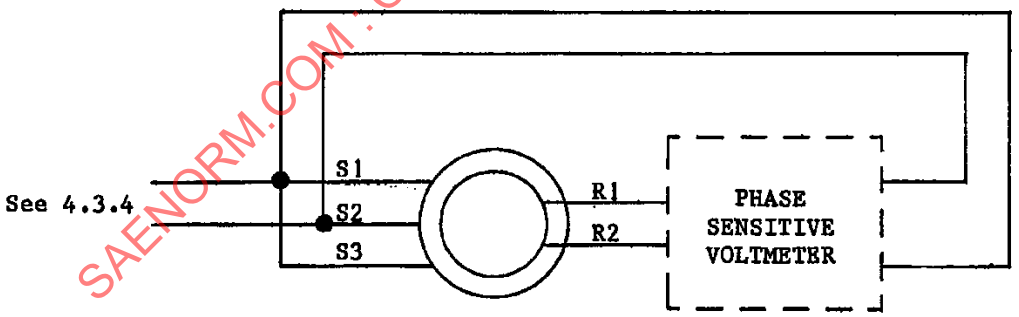
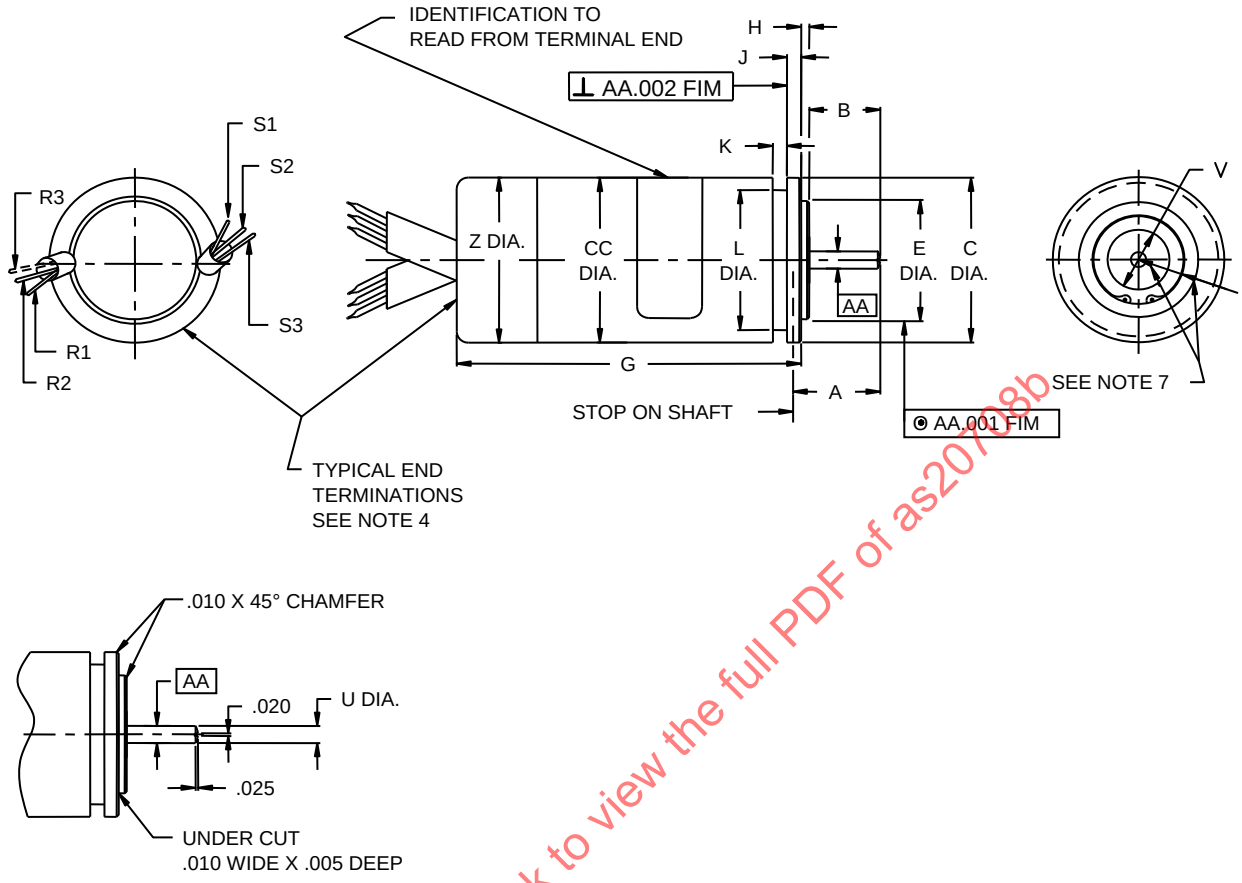


FIGURE 3 - DIAGRAM FOR DETERMINING SYNCHRO ZERO POSITION OF CONTROL TRANSFORMERS

NOTE: LETTERED DIMENSIONS ARE SHOWN IN TABLE 3.



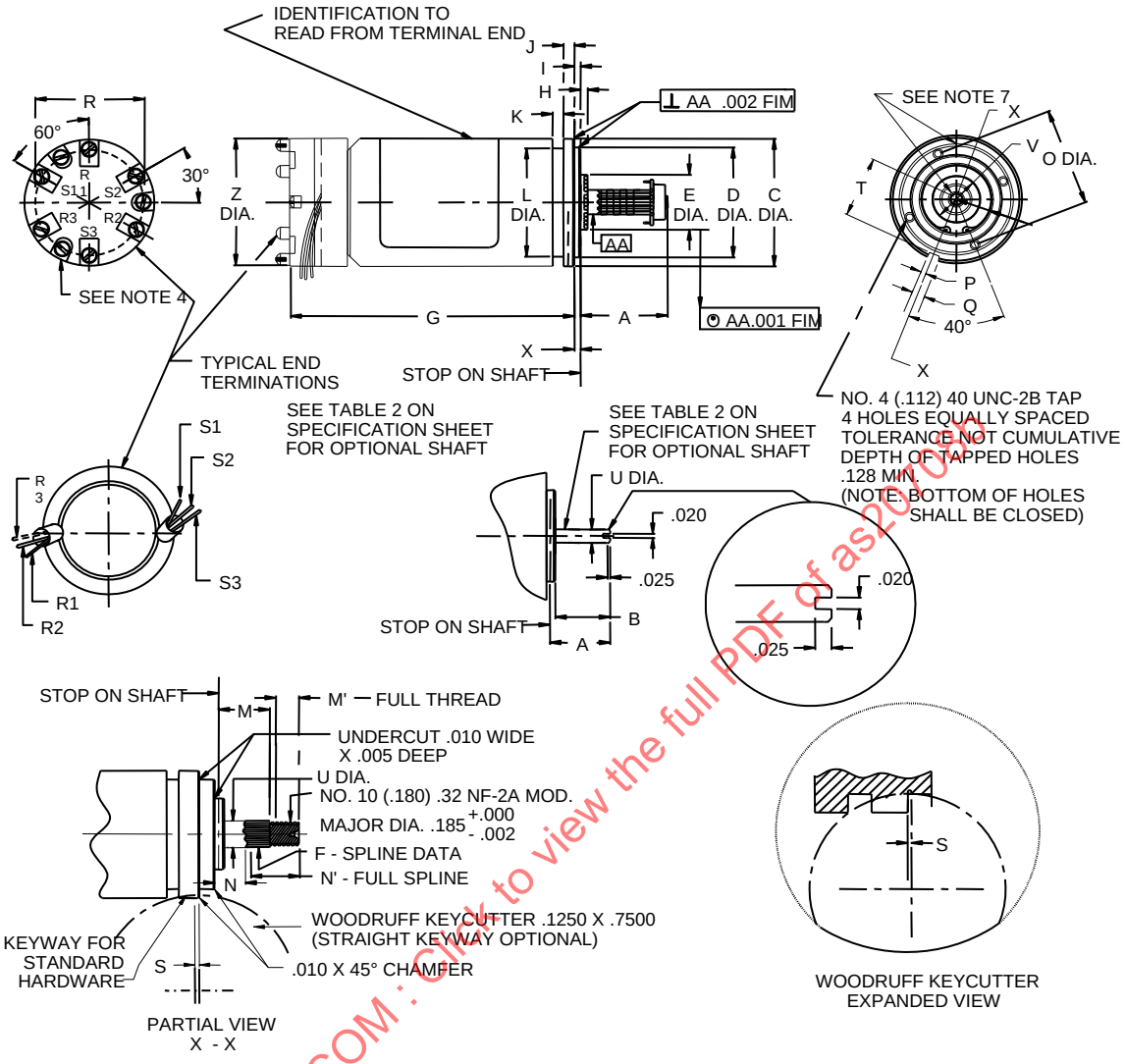
NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED.
2. RUNOUT OF THE SMOOTH PORTION OF SHAFT “AA” SHALL NOT EXCEED .0008 FIM.
3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING THE REVERSAL OF THE FOLLOWING LOADS:

   END PLAY – 0.5 (1/2) POUND RADIAL PLAY – 0.5 (1/2) POUND
4. TERMINAL LEAD WIRES SHALL DEPART THROUGH THE BACK SURFACE OF THE TERMINAL END OF THE SYNCHRO IN ANY ACCEPTANCE MANNER.
5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL.
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.
   TOLERANCES ON FRACTIONS ± 0.015625 (1/64), DECIMALS ± 0.005, ANGLES ± 2 DEGREES.
7. MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10 DEGREES, WHEN ROTOR IS SET AT APPROXIMATELY SYNCHRO ZERO AND WILL BARE NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING.
8. DIELECTRIC WITHSTANDING TEST POTENTIAL SHALL BE 500 + 0 / - 15 V RMS FOR INITIAL APPLICATIONS AND 400 ± 12 V RMS FOR SUBSEQUENT TESTS. THE INSULATION RESISTANCE TEST SHALL BE PERFORMED, WITH A DC POTENTIAL OF 250 V.

FIGURE 4 - OUTLINE DRAWING FOR SIZE 05 AND 08 SYNCHROS

NOTE: LETTERED DIMENSIONS ARE SHOWN IN TABLE 3.



NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED.
2. RUNOUT OF THE SMOOTH PORTION OF SHAFT “AA” SHALL NOT EXCEED .0008 FIM.
3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING THE REVERSAL OF THE FOLLOWING LOADS:

   END PLAY - 1 POUND RADIAL PLAY – 0.5 (1/2) POUND
4. THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS. RECESSES SHALL ALLOW TERMINAL LUGS, AS25036-148 AS SPECIFIED IN AS25036 OR AS7928/12-148 AS SPECIFIED IN AS7928/12 (WHEN TIN WHISKER GROWTH MAY OCCUR), TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD, AND PREVENT THE LUGS FROM TURNING.
5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL.
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.
   TOLERANCES ON FRACTIONS ± 0.015625 (1/64), DECIMALS ± 0.005, ANGLES ± 2 DEGREES.
7. MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10 DEGREES, WHEN ROTOR IS SET AT APPROXIMATELY SYNCHRO ZERO AND WILL BARE NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING.
8. FOR ALTITUDE TESTING, TEST VOLTAGE SHALL BE 300 V DC FOR ALL UNITS OVER 50 V.

FIGURE 5 - OUTLINE DRAWING FOR SIZE 11 AND 15 SYNCHROS