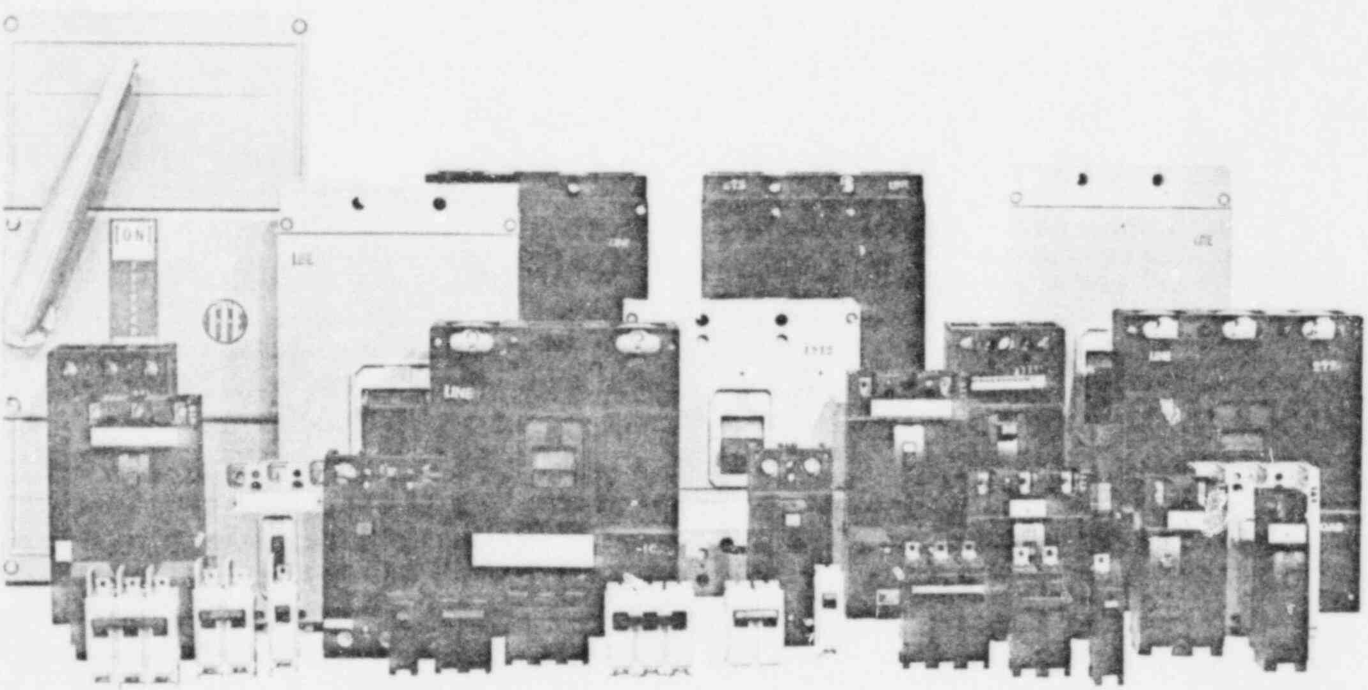
Bulletin 2.0.1 - 2A

Gould I-T-E Molded Case Circuit Breakers Testing and Maintenance Procedures



GOULD

YOU'LL FIND MANY REASONS FOR CHOOSING I-T-E MOLDED CASE CIRCUIT BREAKERS

Here Are Just a Few:

Maximum protection for equipment and personnel. Minimum maintenance and downtime.

Lower total cost over the many years of service you'll get from I-T-E breakers. Because they're resettable, take less space, consume less power and prevent single phasing as compared to fusible devices.

A selection to meet any need you may have. From a 4000-ampere systems breaker to a 15-ampere ground fault interrupter, an instantaneous-trip breaker for motor protection, a special fire-pump breaker, or—the most demanding of all—breakers to meet U.S. Navy requirements.

Capability to do virtually anything you want, anywhere you want. With over 800 breakers to choose from, you also have a complete variety of accessories, auxiliaries, enclosures and mounting arrangements. You may find you can do things with an I-T-E breaker you never dreamed were possible with any protective device.

The utmost in reliability, based on I-T-E's quality construction—quick-make, quick-break operation, silver alloy contacts, high contact pressure, extra-wide pole spacing, individually calibrated poles on all breakers. These and many other design and construction features are checked constantly to meet I-T-E's quality requirements and those of Underwriters' Laboratories, Inc. All of these measures of dependeable protection are the natural results of I-T-E's many years of technical leadership in circuit breakers.

For testing procedures on GFI and Systems Breakers, consult appropriate manuals.

I-T-E molded case circuit breakers undergo extensive production testing and calibration at the factory. These tests are based on Underwriters' Laboratories, Inc. "Safety Standard for Branch Circuit and Service Circuit Breakers" No. 489. Circuit breakers carrying the UL label have factory sealed calibrated elements; an unbroken seal assures that the mechanism has not been subjected to alteration or tampering, and that the breaker may be expected to perform according to the UL specifications. A broken seal voids the UL label and jeopardizes the warranty.

I-T-E molded case circuit breakers have an excellent record of reliability which to a great extent is due to the enclosed design which minimizes tampering and exposure to dirt, dust, and other contaminants. This reliability also depends on proper installation following careful application, particularly with reference to the maximum available short-circuit current of the circuit to which the circuit breaker is applied.

Reliability after application also depends upon environment and maintenance. All devices with moving parts require periodic check-ups. A circuit breaker is no exception. It is not unusual for a circuit breaker to be in service for extended periods and never be called upon to carry out its overload or short-circuit functions. Therefore, it should be exercised and tested at times to assure proper functioning. The procedures outlined in this bulletin are accepted methods of testing to verify circuit breaker performance in the field.

CAUTION

Molded Case Circuit Breakers must always be completely de-energized, disconnected and isolated before any tests or maintenance are attempted.

Qualified, authorized personnel can perform routine field testing and maintenance to assure the circuit breaker is providing proper protection.

These procedures are based on accepted practices. Note the caution below before beginning any tests.

1) Connections Test

The connections to the circuit breaker terminals should be inspected to determine proper conductor ampacity and that proper electrical joints exist. If overheating of connections is evident by discoloration or arcing, the surfaces must be cleaned before testing and reinstallation. As stated before, it is essential that electrical connections be made properly to prevent overheating. Refer to Table #2 on page 7 for recommended torque values. Aluminum lug connectors are plated and should not be cleaned with abrasives.

2) Mechanical Operation Check

Manual mechanical exercising of a circuit breaker is a recommended procedure. A few operations of the handle performed periodically, together with a careful visual inspection of terminal connections, for tightness, physical damage or evidence of overheating are considered good practice. This will keep mechanical linkages free, while the wiping action by contacts tends to avoid resistance build-up and thereby minimizes heating. Circuit breakers applied and specified for switching duty do not need regular exercising.

3) Individual Pole Resistance Test (Millivolt Drop)

The detrimental effect of operating a circuit breaker in a manner for which it was not intended can be detected by making a millivolt drop test across the line and load terminals of each pole of the unit with the circuit breaker contacts closed.

I-T-E will provide allowable voltage drop data on request for circuit breakers under test. It is recommended that this test be made with a dc current approximating 50 percent of the circuit breaker continuous current rating; however, currents for the larger circuit breakers may be as low as 50 amperes if the millivoltmeter is of sufficient sensitivity. The millivolt drop across each pole is measured and recorded for comparison against the data submitted by Gould. Without such data it may be practical to compare values with those of poles of other circuit breakers of similar size and style.

4) Overload Tripping Test

This test provides assurance the overload component of the circuit breaker is operating. This is NOT a verification test of I-T-E's published test data. To perform the test, apply 300% of the breaker rating. The breaker should open automatically. This proves the overload component is functioning. To determine actual tripping characteristics, refer to page 5.

5) Instantaneous Magnetic Tripping

This test provides assurance that the instantaneous magnetic component of the circuit breaker is functioning. This test does NOT determine exact tripping values. To perform the test, use either the Runup or Pulse method described on page 6.

6) Insulation Resistance

An insulation resistance test is used to determine the quality of insulation between adjacent poles of a circuit breaker and from its poles to ground.

The resistance test is made with higher dc voltage than the rated voltage, to determine the actual resistance of the insulation. The most common method employs a "megger" type instrument. Most of such devices in use have outputs of 500 voltes or less, whereas, much more reliability will be derived if 1000 volt instruments are used because they are more likely to pick up tracked insulation surfaces. Resistance values below one megohm are considered unsafe and should be investigated.

An insulation resistance test should be made:

- Between line and load terminals of individual poles with the circuit breaker contacts open.
- Between adjacent poles and from poles to metallic supporting structure with the circuit breaker contacts closed. The latter may be done with the circuit breaker in place after the line and load conductors are removed, or with the circuit breaker bolted to a metallic base which simulates the in-service mounting.

7) Summary

It is again emphasized that common maintenance practices for electrical equipment should be adhered to in field testing both new and installed molded case circuit breakers, and usually the standard routine operating checks listed above will be sufficient to assure proper functioning of the circuit breaker. It is further recommended that since molded case circuit breakers have factory sealed calibrated elements, that THIS SEAL SHOULD NOT BE BROKEN AND THE CIRCUIT BREAKER ITSELF SHOULD NOT BE TAMPERED WITH.

Adjustment or repair o' molded case circuit breakers in the field is not recommended. The circuit breaker should be replaced, or its parts should be replaced or repaired at the factory.

After performing any of the above tests, be certain to account for all hardware and tools and make certain all test instruments are disconnected before re-energizing the circuit breaker.

CAUTION

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Underwriters Laboratories, Inc. "Standard for Molded Case Circuit Breakers and Circuit-Breaker Enclosures," UL 489, is the basis for performance standards for all molded case circuit breakers bearing the UL label. Verification of molded case circuit breakers to UL test standards is intended to permit the checking of circuit breakers in accordance with published data under carefully controlled conditions. The published data are based upon the UL standard and, if verification of these data or application curves is desired from tests, the tests should be performed under carefully controlled conditions as specifically instructed by Gould I-T-E.

If circuit breaker performance characteristics are to be tested in the field, there are many variables that must be recognized and taken into account. Some simplifications are necessary; however, even simplified testing must recognize variations that can and do exist between one test setup and another. These variations can account for differences in test results, and it must be recognized that a circuit breaker may furnish adequate protection, but appear defective because of the test procedure used.

Underwriters Laboratories Standards

Calibration standards and the trip-time values for circuit breakers tested in accordance with UL 489 are based on the following conditions:

1. Circuit breakers are tested in open air at an ambient temperature of 25°C (77°F).
2. UL trip time values are measured from a "cold start." Therefore, before tests are started, circuit breakers must have been in a 25°C ± 3°C (77°F ± 5°F) ambient long enough for all parts to have reached the same temperature (at least 2 hours for circuit breakers rated 100 amperes and below, and 4 hours for those rated above 100 amperes).
3. Calibration tests are made with conductors of the size specified in the UL Standard connected to line and load terminals. If, in field testing, the circuit breaker is connected with wire or bus other than that specified, results will vary from published data. The wire should be connected with the lug specifically intended for that breaker, and both the lug mounting screw and cable set screw should be properly secured.
4. Current must be held constant and accurately over the entire test time. The heat generated in the trip unit of a thermal trip circuit breaker is proportional to the square of the current. A small variation of current can cause a large variation in total heat generated.

   Example—if a 10-ampere current (I_1) is allowed to change only 10 percent to 11 amperes (I_2), the heat generated will be:

   $$\frac{(I_2)^2}{(I_1)^2} = \frac{11^2}{10^2} = \frac{121}{100} = 121\%$$

   This shows that an increase of 10 percent in current will cause a 21 percent variation in heat and a corresponding error in trip time.

NOTE—To get field test results comparable to those obtained when circuit breakers are factory tested to UL Standards, ammeters must be carefully checked to a precise standard. *Most panel instruments are accurate to a ± 2 percent of full scale reading.* This means that a 500-ampere meter may have an error of ± 10 amperes (+ 0.02 X 500 = ± 10 amperes). This same 10-ampere error can exist during measurements at all points on the scale. For example, the error at 100 amperes or 1/5 scale may still be 10 amperes, i.e., 10 percent. From the previous example, a 10-percent change in current can cause a 21-percent change in heat in the circuit breaker under test and a corresponding change in trip time. In order to minimize this effect, meter scales should be chosen so that readings are taken in the upper half of the scale.

Testing Limitations

In field testing it will not be practical to meet all of the test conditions specified by UL Standards. In many cases, NONE of the UL standard factory test conditions may be fully met.

One of the most frequently encountered problems is the fact that a circuit breaker may have to be tested in the enclosure in which it is mounted, rather than in open air as specified by UL. Consequently, the difference in ambient temperature will result in tripping characteristics different from those which would be experienced in open air.

Temporary test connections call for extra care with respect to the tightness of the connections and the size of the conductor in order to reduce heating and voltage drop.

Other frequently encountered problems are the inability to wait the required time for the circuit breakers to cool to room temperature and a room temperature other than 25°C (77°F). If tests are made while thermal-trip circuit breakers are still warm, the trip time will be shorter than if they were allowed to cool completely. When testing individual poles, successive tests can be run on adjacent poles, with no cool-down periods between tests without resulting in more than a 10 percent error.

The recommended method of determining whether a circuit breaker has been calibrated in accordance with Gould I-T-E's limits is to *meet* all of the UL specified conditions outlined in this publication.

Molded Case Circuit Breaker Trip Characteristics

Gould I-T-E molded case circuit breakers employ the inverse time element principle as the design basis for protecting against overloads without nuisance tripping. With the inverse time element concept, the time between the occurrence of an overload and the moment of tripping varies inversely with the magnitude of the overload current. Thus, optimum overload protection is achieved without nuisance tripping from momentary higher overload currents. The speed of the breaker's response depends on the magnitude of the overload.

The basic Gould I-T-E thermal magnetic molded case circuit breaker combines the inverse time element or thermal action design for low level overloads, and instantaneous magnetic action for short circuits.

Thermal Overcurrent Trip Test

When testing molded case circuit breakers in the field, it is recommended that the thermal overcurrent tests be performed on individual poles at 300% of rated current. The reaction of the circuit breaker to this overload will be indicative of its reaction throughout its entire overcurrent tripping range. This load has been chosen as the test point because it is relatively easy to generate the required current in the field and the wattage per pole from line to load is large enough so that the dissipation of heat in the adjacent pole is minor and does not affect the test results appreciably.

CAUTION

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VERIFICATION TEST RESULTS

Test values are based on 300% of breaker rating on individual poles at 25°C (77°F) using four feet of copper wire or cable as indicated.

Breaker Frame	Ampere Rating	Wire Size Per Pole	Tripping Time In Seconds Minimum	Tripping Time In Seconds Maximum	Max. For Cable Prot.
EQ 1-Pole	15-20	1—#12	4	45	100
	30-50	1—#6	4	45	100
EQ 2,3 Pole	15-20	1—#12	4	35	100
	30-40	1—#8	4	35	100
	50-100	1—#1	5	45	200
	125	1—#1/0	10	50	200
BQ-C	15-20	1—#12	4	35	100
	30	1—#10	4	35	100
QJ	125-225	1—#4/0	25	155	300
E	15-20	1—#12	8	50	100
	30-40	1—#8	8	50	100
	50-100	1—#1	9	50	200
EH, EF, HE HE	15-20	1—#12	10	50	100
	30-40	1—#8	10	50	100
	50-100	1—#1	9	75	200
EH	110-150	1—#1/0	25	180	300
FJ	70-100	1—#1	30	130	200
	125-225	1—#4/0	35	170	300
JD, JJ JL, HJ	70-100	1—#1	50	130	200
	125-225	1—#4/0	40	160	300
	250-400	2—#3/0	30	200	300
LL, HL	450	2—#4/0	25	250	300
	500-600	2—350 MCM	25	250	350
KM	250-450	2—#4/0	70	250	300
	500-600	2—350 MCM	45	250	350
	700-800	3—300 MCM	55	280	600
HM	400-450	2—#4/0	45	250	300
	500-600	2—350 MCM	45	250	350
	700-800	3—300 MCM	45	280	600
KP, HK	600	2—350 MCM	25	250	350
	700-800	3—300 MCM	25	450	600
	900-1200	4—350 MCM	25	450	600
HP	600	2—350 MCM	35	250	350
	800-1200	4—350 MCM	35	350	600
	1400-1600	5—400 MCM	100	400	750
HR	1800-2000	5—600 MCM	170	450	750
HS	2500	8—400 MCM	25	600	750
	3000	9—400 MCM	25	600	750
	4000	12—400 MCM	25	600	750
CC	15-20	1—#12	5	40	100
	30	1—#10	5	40	100
CE	15-20	1—#12	7	35	100
	30-40	1—#8	7	35	100
	50-100	1—#1	9	100	200
CJ	150-225	1—#4/0	45	200	300
	250-400	2—#3/0	35	200	300
CM	400-450	2—#4/0	30	280	300
	500-600	2—350 MCM	30	280	350
	700-800	3—300 MCM	70	400	600
CP	600	2—350 MCM	35	250	350
	800-1200	4—350 MCM	75	430	600
	1400-1600	5—400 MCM	230	550	750
CR	1800-2000	5—600 MCM	260	550	750

EVALUATION OF FIELD TEST RESULTS

Minimum Tripping Times

The minimum values shown in the above table should not be considered significant in field testing unless nuisance tripping has been experienced. These values are provided as a guideline only. If minimum tripping times are lower than those shown in the table, the breaker shoul be retested after being de-energized and cooled for the required time.

Maximum Tripping Times

Under normal conditions, the circuit breaker will trip in less time than the maximum values shown in the table. Under improper test conditions, the maximum values may exceed those given in the table.

Maximum Tripping Times For Cable Protection

If the test value exceeds the maximum tripping time shown in the above table, but falls below the maximum tripping time for cable damage, the circuit breaker is providing an acceptable level of protection. Coordination with other protective devices should be considered before replacing a circuit breaker which trips beyond the time-current curve.

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INSTANTANEOUS MAGNETIC OVERCURRENT TRIP TEST

These tests are intended to simulate short-circuit conditions, but it must be remembered that in the field it is practically impossible to impose the 5000 amperes (or more) pulse that is imposed in the laboratory.

In routine tests it is more important to determine that the magnetic trip feature is operating and will trip the circuit breaker, rather than determining the exact current value at which the magnetic trip feature operates. To duplicate Gould I-T-E's published data, exact determination of trip current values can be obtained, but the necessary precise control of test conditions will probably prove impractical. It must be recognized that on circuit breakers in the larger frame sizes the instantaneous magnetic overcurrent trips have adjustable settings, usually from 6 (Lo) to 10 (Hi) times the continuous current rating.

Since the magnetic trip characteristics of the circuit breaker can be influenced by stray magnetic fields, the test setup must be made in such a way that the fields caused by the test equipment itself, by steel enclosures, or by the conductors to the circuit breaker, do not affect the test results. Results can also be greatly influenced by the wave shape of the current and, therefore, it is desirable to have sinusoidal output from the loading equipment.

Testing of the instantaneous magnetic trip feature may be by the "runup" method or the "pulse" method:

1. *Runup Method*—In this method, one pole of the circuit breaker to be tested is connected to the test equipment, and the current control is set at a point where approximately 70 percent of the expected tripping current will flow when energized. The power is then turned on and the current increased until the circuit breaker trips. The recommended time for increasing the current is between 2 and 5 seconds. If the current is increased too slowly, tripping may be due to the time-delay element, especially if more than one test is run at a high current level. If the current is increased too rapidly, an erroneous current reading may be obtained because the meter indication lags behind the actual current value due to meter damping.

   The runup method requires skill on the part of the operator in recognizing the relationship between actual current and the meter indication.

   CAUTION—If the circuit breaker does not open within 10 seconds, the loading circuit must be de-energized to protect it from damage.

2. *Pulse Method*—This method will be more accurate than the runup method if done properly, but it requires that the test equipment be equipped with a pointer-stop ammeter or a calibrated image-retaining oscilloscope. It involves the following steps:

   a. After the circuit breaker is connected, current is applied in short pulses of 5 to 10 cycles.

   b. The current is increased on each succeeding pulse until the circuit breaker trips.

   c. The current is then reduced to just below that point and, by repeated pulses, the pointer stop on the ammeter is adjusted until the pointer movement is barely perceptible when the current is pulsed.

   d. The current can then be raised slightly and rechecked at the current at which the circuit breaker trips.

Although this method is a more accurate procedure, it is subject to an error introduced by current offset. Figure #1 depicts the distortion of the pulse current, commonly called offset or asymmetrical.

An offset current results from closing the circuit at that point of the cycle where the voltage-current relationship results in an asymmetrical current. Experience with field test equipment indicates that the offset may be as high as 20 percent. A circuit breaker can be tripped by the offset peak rather than the steady-state current so the effect of the error is such that the indicated trip current may be as much as 20 percent lower than the peak offset current which tripped the circuit breaker. In factory testing, this error is avoided by (1) using synchronous closing of the current control to make contact at a point on the 60-hertz wave so that no offset current occurs, and (2) reading current values on a calibrated image-retaining cathode ray oscilloscope or a graphic recorder.

Interpretation of Test Results

The principal purpose of field testing is to permit the user to safely determine whether the circuit breaker is furnishing the protection for which it is intended, or whether it should be replaced. Field testing is *not* intended to determine whether the circuit breaker exactly meets the published curves. A circuit breaker that trips in *less* than the minimum time shown by the time current characteristic curves may furnish more protection than is expected. System coordination of tripping times should be considered before replacing a circuit breaker that trips at a value outside of the time-current curve.

CAUTION
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RECOMMENDED TORQUE VALUES

Breaker Frame	Lug Cat. No. or Wire Range	Cable Set Screws	Lug Mounting Screws
QT	#14 to #10 AWG. CU (15-30A)	20 in. lbs.	–
	#12 to #8 AWG. AL (15-30A)	20 in. lbs.	–
	#8 AWG. CU; #6 AWG. AL (40A)	35 in. lbs.	–
Load Lugs	#14 to #8 AWG. CU (15-30A)	20 in. lbs.	–
QP, HQ	#12 to #8 AWG. AL (15-30A)	20 in. lbs.	–
BQ, HB	#8 to #1 AWG. CU/AL (40-70A)	50 in. lbs.	–
	#4 to 1/0 AWG. CU/AL (90-125A)	50 in. lbs.	–
Line Lug BQ, HB	TC1-Q1	50 in. lbs.	–
Load Lug	#14 to #10 AWG. CU (15-30A)	20 in. lbs.	–
CC	#12 to #8 AWG. AL (15-30A)	20 in. lbs.	–
Line Lug	#14 to #10 AWG. (15-30A)	20 in. lbs.	25 in. lbs.
CC	#12 to #8 AWG. (15-30A)	20 in. lbs.	25 in. lbs.
QJ	TA1-Q300	250 in. lbs.	96 in. lbs.
	TC1-Q250	250 in. lbs.	96 in. lbs.
E, EH, EF, HE, CE	TA1-E010 (15-25A)	20 in. lbs.	
	TA1-E100 (30-100A)	50 in. lbs.	55 in. lbs.
150 Amp EH, 150 Amp EF	TA1-E150	100 in. lbs.	50 in. lbs.
	TC1-E150	100 in. lbs.	50 in. lbs.
FJ	TA1-F300	250 in. lbs.	96 in. lbs.
	TC1-F250	250 in. lbs.	96 in. lbs.
JJ, JL, HJ, CJ	TA1-J300	250 in. lbs.	210 in. lbs.
	TA1-J500	300 in. lbs.	210 in. lbs.
JP	TA2 J250	250 in. lbs.	96 in. lbs.
LL, HL	TA2-J500	300 in. lbs.	240 in. lbs.
KM	TA2-K500	300 in. lbs.	96 in. lbs.
	TA3-K350	250 in. lbs.	96 in. lbs.
	TA3-K400	250 in. lbs.	96 in. lbs.
	TC2-K500	300 in. lbs.	96 in. lbs.
	TC3-K350	250 in. lbs.	96 in. lbs.
HM, CM	TA2-M350	250 in. lbs.	240 in. lbs.
	TA3-M400	250 in. lbs.	240 in. lbs.
	TA4-M350	250 in. lbs.	240 in. lbs.
	TA4-M500	300 in. lbs.	240 in. lbs.
	TC2-M400	250 in. lbs.	240 in. lbs.
	TC2-M500	300 in. lbs.	240 in. lbs.
	TC3-M400	250 in. lbs.	240 in. lbs.
	TC3-M500	300 in. lbs.	240 in. lbs.
KP, HK	TA4-P500	250 in. lbs.	240 in. lbs.
HP, HR, CP, CR	TA5-P600	300 in. lbs.	300 in. lbs.

Values Shown Are ±5 in. lbs.

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