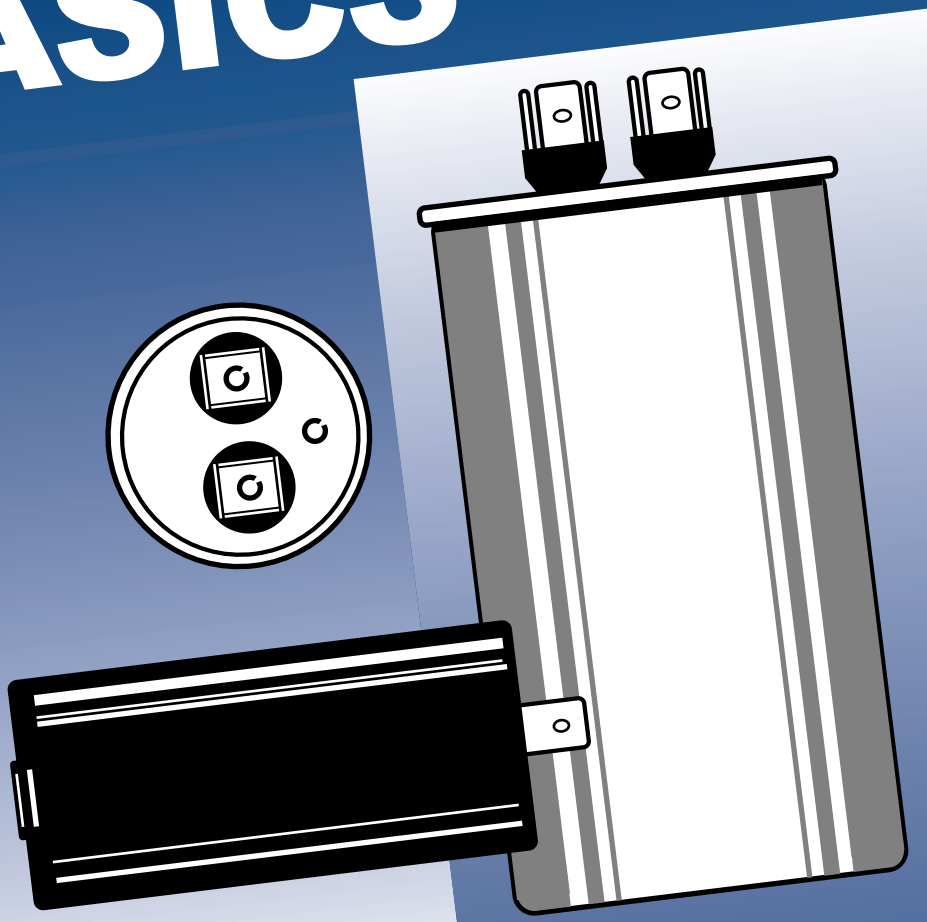
CAPACITOR BASICS



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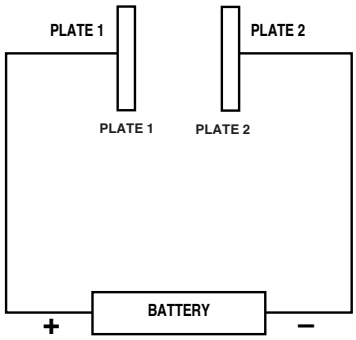
CAPACITORS

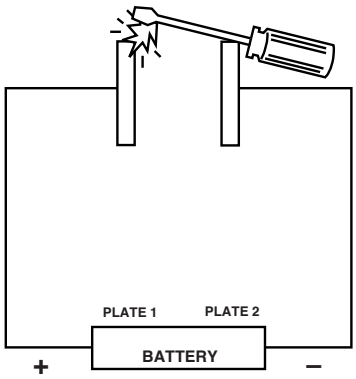
1. *INTRODUCTION:* The purpose of this brochure is to provide practical information about Motor Starting and Motor Run Capacitors as they apply to the Air Conditioning, Refrigeration and Heating service industry. A basic understanding of electricity and electric motors is helpful if one is to derive the most benefit from the presentation.

While this report is primarily written for service technicians, it is also worthwhile reading for wholesaler sales people so they may knowledgeably assist their customers in selecting a capacitor.

2. *WHAT IS A CAPACITOR? HOW DOES IT WORK?:* Very simply, a capacitor is a device that stores and discharges electrons. While you may hear capacitors referred to by a variety of names (condenser, run, start, oil, etc.) all capacitors are comprised of two or more metallic plates separated by an insulating material called a dielectric.



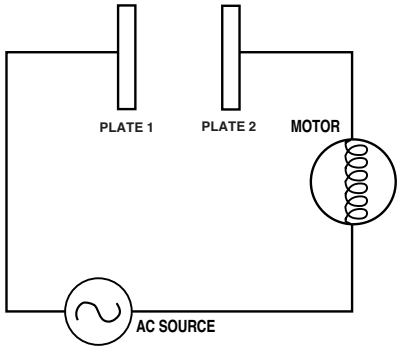
A very simple capacitor can be made with two plates separated by a dielectric, in this case air, and connected to a source of DC current, a battery. Electrons will flow away from plate 1 and collect on plate 2, leaving it with an abundance of electrons, or a “charge”. Since current from a battery only flows one way, the capacitor plate will stay charged this way unless something causes current flow.



If we were to short across the plates with a screwdriver, the resulting spark would indicate the electrons “jumping” from plate 2 to plate 1 in an attempt to equalize. As soon as the screwdriver is removed, plate 2 will again collect a charge.

Now let’s connect our simple capacitor to a source of AC current and in series with the windings of an electric motor. Since AC current alternates, first one plate, then the other would be charged and discharged in turn.

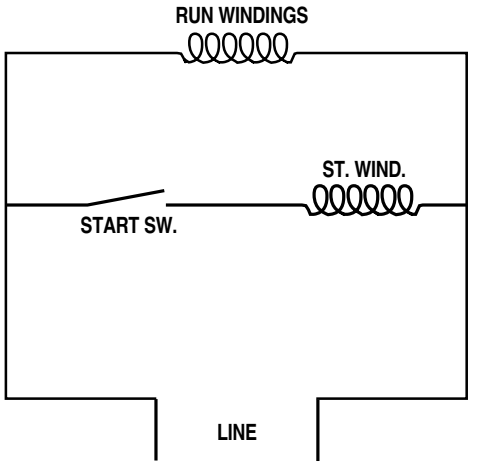
First plate 1 is charged, then as the current reverses, a rush of electrons flow from plate 1 to plate 2 through the motor windings. When the current reverses again the electrons will rush back to plate 1.



Note that electrons do not pass through the capacitor but rather travel back and forth, from one plate to the other, through the motor windings. This rush of electrons, first one way then the other, has a desirable effect when applied to certain motors.

3. *WHAT EFFECT DOES A CAPACITOR HAVE ON A MOTOR?:*

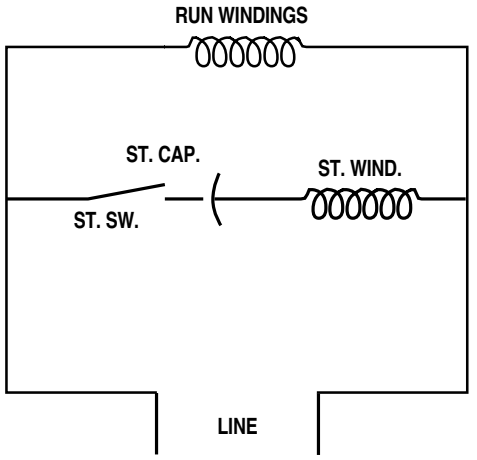
Simple Split Phase Motor



Simple Split Phase Motor:
Common split phase motors have two sets of windings, start and run. Start windings are used to overcome inertia and allow the motor to start under load. Start windings are wound with smaller wire and many more turns than run windings. This greater resistance, as compared to the run winding, causes the current in the run winding to lag behind that of the start. The effect is much the same as two phase current. The motor can start and when up to about 3/4 speed, the start switch opens and causes the start winding to drop out of the circuit.

It is the “out-of-phase” condition between the start and run windings that produce the torque needed to start the motor under load.

Capacitor Start Motor



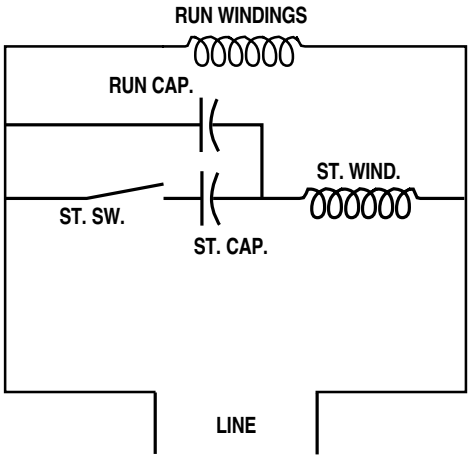
Capacitor Start Motor:
A start capacitor is added in series with the start winding. The effect is to throw the current in the start winding even further “out-of-phase” than can be accomplished by the resistance of the start winding alone.

The result is even greater starting torque. Typically, an increase is from 300% to 500%. It also decreases the starting current and increases the voltage on the start winding from the circuit.

As with a simple split phase motor, when speed increases to about 3/4 of full speed, the starting switch will open and remove the start capacitor and start winding from the circuit.

NOTE: Since start windings are made of small size wire and produce high resistance, they would quickly burn out if left in the circuit beyond the time it takes to bring the motor to 3/4 speed. Start windings can fail for a variety of reasons which will be covered later.

Capacitor Start - Capacitor Run Motors

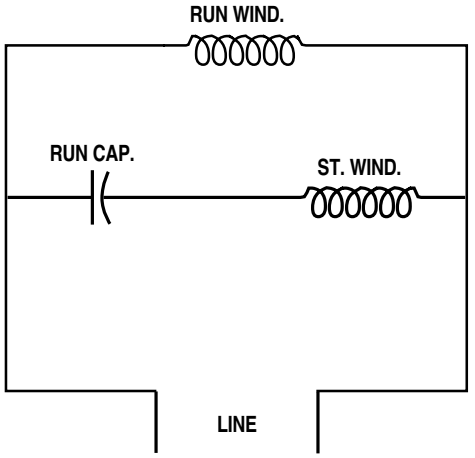


WHAT EFFECT DOES A CAPACITOR HAVE ON A MOTOR?: (CONTINUED)

Capacitor Start - Capacitor Run Motors:
In addition to the start capacitor, a run capacitor is now added in series with the start winding and parallel to the start capacitor. While the start capacitor "drops out" when the motor reaches 3/4 speed, the run capacitor stays in the circuit at all times with the start winding. Its purpose is to improve the power factor of the motor during running and reduce current consumption. Although its purpose is not to aid in starting the motor, we shall see later that it does have a small positive effect when starting.

Run capacitors have far lower capacitance and much different construction and appearance than start capacitors.

PSC Motor



Permanent Split Capacitor (PSC) Motors:
This type motor is a split phase motor with the addition of a run capacitor in series with the start winding. No starting switch is used, so the capacitor and start winding are in the circuit at all times. The motor is so constructed to allow for this without burning the start winding. A PSC motor has low starting torque but is very efficient in operation and generally costs less that a capacitor start-capacitor run motor.

To increase starting torque, most PSC motors can be fitted with a so called "hard start kit" comprising of a potential relay and start capacitor. Recently, the development of positive temperature co-efficient resistors (PTCR) has allowed solid state technology to be used to increase starting torque in PSC motors in place of the traditional hard start kit. More on this will be covered under "Application" section.

4. *TYPES OF CAPACITORS & CONSTRUCTION:*

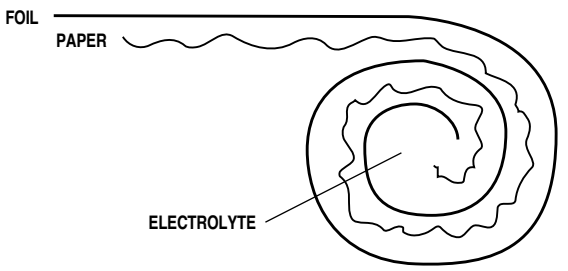
A capacitor, as mentioned previously, is comprised of two metallic plates separated by some insulating material commonly called a dielectric. The ability of a capacitor to store electrons is known as its capacitance and is rated in microfarads, abbreviated mfd. A microfarad is one millionth of a farad.

The capacitance is dependent on the area of the plates, the distance between plates, and the stability of the insulation. Of these, the area of the plates, is most important in determining capacitance. All else remaining constant, an increase in plate area will yield an increase in capacitance.

Since we have already seen that capacitors are used for different purpose, i.e.: motor start or motor run, there are different methods of construction used to produce capacitors. They are usually referred to by either type of dielectric employed or by the function they perform.

4. *TYPES OF CAPACITORS & CONSTRUCTION: (CONTINUED)*

Motor Start (Electrolytic) Capacitors:
Start capacitors are comprised of compactly wound aluminum foil separated by layers of paper, all of which is impregnated by a conducting electrolytic which creates the effect of two plates and a dielectric. The capacitor is housed in a sealed phenolic container.



Start capacitors are designed for intermittent duty only, typically for no more than 20 starts per hour, with each starting period not to exceed three seconds. Longer starting periods or more frequent starts will lead to excessive heat rise within the capacitor and cause premature failure.

Start capacitors are rated in microfarads and voltage. Ratings typically run from 100 VAC to 300 VAC and from 21 thru 1200 mfd. Proper selection of start capacitors is important and will be covered under “Application”.

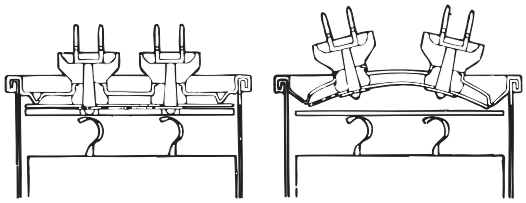
Motor Run Capacitors:
Unlike the plastic housing of the start capacitor, the run capacitor is typically enclosed in a drawn, seamless metal can. While early run capacitors were round, today most are oval in cross section. This is because one day a General Electric engineer realized that if the roll of the capacitor was compressed, it could fit into an oval can and save space. Years ago, this type of construction was known as a “Gregg Oval” in honor of the inventor.

A run capacitor, unlike a start, is designed for continuous duty. It is in the circuit whenever the motor is running. They typically have much lower mfd ratings that start capacitors; usually from 2 to 60 mfd. The common voltage ratings are 370 and 440 VAC.

The purpose of the oil (or other fluid today) is to increase the dielectric strength of the paper or polypropylene and to act as a heat sink. Remember, run capacitors are continuous duty devices and the large quantity of fluid helps dissipate the heat before it can adversely affect the capacitor. Oil has a tendency to lose dielectric strength as temperature increases.

About 35 years ago, oil was replaced with a chemical substance containing Polychlorinated biphenyl or PCB. PCB is a wonderful dielectric and heat sink, however, it is injurious to the environment and has been banned by the EPA. This led to the search for another dielectric and several have been developed that exhibit all the desirable characteristics of PCB’s while being environmentally safe.

The only drawback to these new compounds is that they are flammable. If the heat increased too much, the resulting pressure rise could burst the capacitor and start a fire. Therefore, all non-PCB capacitors incorporate a physical interrupter to prevent excessive pressure rise.



PHYSICAL INTERRUPTER

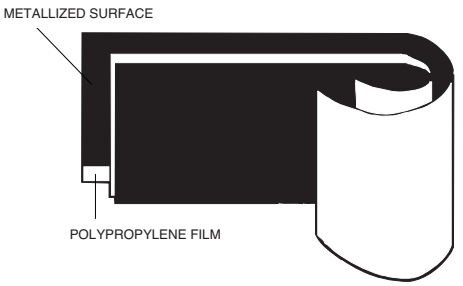
As the pressure within the capacitor increases, the top of the can “pops” upward, breaking the connection between the terminals and the plates.

Motor run capacitor construction has evolved over the past twenty years from a traditional use of paper, foil, and a PCB-based impregnating oil, to two basic modern types.

4. *TYPES OF CAPACITORS & CONSTRUCTION: (CONTINUED)*

Impregnated Metallized Capacitors:

The newest technology in capacitor design is metallized film capacitors. In operation and application, they serve the same purpose as conventional run capacitors, but their construction is very different.



Rather than using sheets of foil separated by several layers of paper to create the plates and insulation, metallized capacitors use sheets of polypropylene film onto which is "sprayed", or metallized, a thin layer of metal. Two metallized films are then wound together very tightly to form the capacitor.

The resulting roll is very hard and cannot be squeezed into a traditional oval shape.

Therefore, many metallized film capacitors are round. They are, however, much smaller than conventional run capacitors. A 35 mfd, 440 volt metallized capacitor is 50% smaller than an oil paper capacitor. It also weighs 60% less because there is much less liquid in a metallized capacitor. Many oval shaped run capacitors are now metallized film. The "roll" is small enough to fit into the oval can previously used for film/paper construction. Retaining the oval shape is important for the replacement market.

We learned previously that run capacitors are filled with a liquid that serves to strengthen the dielectric characteristics of the paper and also to dissipate heat. In a metallized capacitor, the liquid is only used as a heat sink. The polypropylene film is an excellent dielectric and requires no assistance. In fact, the capacitor "roll" is wound so tightly that the liquid never penetrates between layers.

The core of a metallized capacitor is surrounded by many layers of plain polypropylene film. This provides excellent insulation between the plates and the metal case and, therefore, no marking is necessary to indicate the neutral terminal.

Finally, metallized capacitors "self heal". The most common cause of capacitor failure is a breakdown of the insulation between plates which leads to a short. If a hole occurs in the metallized film, an arc will jump between the plates. The heat from this arc will vaporize the metal surrounding the hole and self extinguish, thus preventing the short.

Metallized capacitors, because of their smaller size, weight, and longer life expectancy are rapidly gaining favor with equipment manufacturers. In the near future, they will most certainly replace conventional oil-paper run capacitors on new equipment.

Dry-Type:

Dry-Type capacitors are similar in construction to oil-filled, but do not use an oil impregnant. The advantages of dry-type construction are a saving in size, and weight. The possible disadvantages are a lower tolerance to high current failure conditions. Dry-type capacitors are finding their way into more applications as engineers resolve difficulties encountered in field and life testing situations.

Dual and Triple Section Capacitors:

Multi-section capacitors are nothing more than two or three separate capacitor in a common enclosure with one common terminal. They are marked with the voltage rating and the mfd for each section.

Example: 20/4 mfd 370 volt

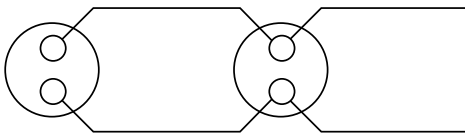
5. *APPLICATION AND REPLACEMENT:*

When replacing a capacitor, it is best to install one of the correct voltage and microfarad rating for the particular motor. Generally, however, a difference of 10% in mfd will not adversely affect the motor.

A problem arises when the proper capacitor is not readily available. While most technicians carry an assortment of popular sizes with them, there is such a wide variety available that he may not always have the proper one at hand. In this case, the correct rating can be achieved by connecting two or more capacitors in parallel or series.

5. *APPLICATION AND REPLACEMENT: (CONTINUED)*

Parallel Connection:
When capacitors are connected in parallel, the mfd rating will be the sum of the individual ratings. This can be expressed in the equation $C_T = C_1 + C_2 + C_3$, etc. The effect of parallel connection is to increase the plate area. The voltage rating of the lowest rated capacitor in the connection becomes the effective voltage of the combination. If a capacitor rated at 125 volts, 180 mfd is required, two capacitors rated at 125 volts, 90 mfd each can be wired in parallel.



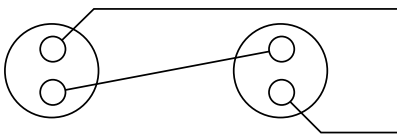
Generally, a capacitor of the same mfd rating but a higher voltage rating can be used as a replacement.

Example: 88-108 mfd 125V - replace with 88-108 mfd 330 volt.

Doing this will generally result in added cost and increased size. A capacitor of correct voltage and MFD rating should be installed at the earliest opportunity.

From this, we can see why the run capacitor of a capacitor start/capacitor run motor slightly aids the motor in starting. Since they are connected in parallel, the total capacitance on start up is the sum of both the start and run capacitor.

Series Connection:
When capacitors are connected in series, the total capacitance is always less than that of the smallest capacitor. The effect of connecting capacitors in series is an increase in dielectric thickness thereby reducing capacitance. The formula for determining total capacitance in series connection is:



$$C_T = \frac{C_1 \times C_3}{C_1 + C_3}$$

Example: Two 250 mfd capacitors connected in series.

$$C_T = \frac{250 \times 250}{250 + 250} = 125 \text{ mfd}$$

The capacitance of two equal capacitors connected in series is one half the value of one capacitor.

The effective voltage when two capacitors are connected in series is the sum of the individual voltage ratings. Therefore, two 250 mfd, 125 volt capacitors in series equals one 125 mfd, 250 volt capacitor. $V_T = V_1 + V_2$.

When connecting capacitors in series, it is best to use two capacitors of equal mfd rating. If capacitors with unequal mfd ratings are connected in series, the voltage will divide across them in inverse proportion to the mfd rating.

Choosing Ratings:
Always select a start capacitor with a mfd rating no more than 10% ± of the one called for. When replacing a run capacitor, never select a lower rating than the one called for. You may exceed the specified mfd as follows:

Specified mfd	Do not add more than
10-20 mfd	+ 2.5 mfd
20-50 mfd	+ 5 mfd
50 and up mfd	+ 10 mfd

5. *APPLICATION AND REPLACEMENT: (CONTINUED)*

When the rating is unknown, it is necessary to consult the manufacturer of the motor for the correct replacement. Capacitors are matched to the internal construction of each motor and, therefore, no standard rule can be applied.

Voltage ratings for start capacitors should match the voltage of the motor, although a higher voltage rating will have no effect, providing the mfd rating is correct. Never use a lower voltage rating as the capacitor will fail.

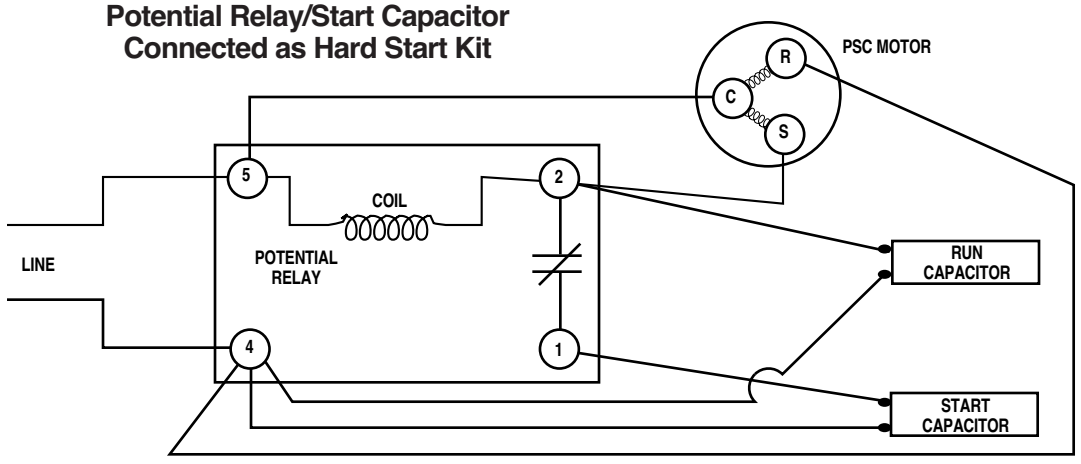
Run capacitors must have a voltage rating higher than the motor. Since run capacitors are in the circuit at all times and connected across both start and run windings, they are subject to line voltage plus the voltages induced by the windings. A 220 volt motor may require a 370 or 440 volt run capacitor. When in doubt, always use the next highest voltage rating.

If the inlet or the discharge of a blower housing using a direct drive blower motor is obstructed, the motor will turn at higher RPM. When this occurs, the induced voltage across the windings will increase. A properly rated capacitor that fails due to high voltage could be an indication of improper air flow due to obstruction. In this instance, the capacitor is acting as a performance fuse. If a higher voltage rated capacitor must be used, do so only as a temporary measure.

Adding Capacitor Hard Start Kits:
Most PSC motors and compressors can be fitted in the field with a potential relay and start capacitor, generally called a hard start kit. This allows the motor to start under a greater load than would normally be possible. It is necessary to consult the manufacturer of a reliable cross reference to select the proper relay and capacitor.

Recently, the development of PTCR's have replaced the hard start kit on certain applications. The PTCR solid state start assist is connected in parallel with the run capacitor of the PSC motor and creates the additional "out-of-phase" effect formerly provided by the relay and capacitor set up. While less expensive and easier to install, the PTCR does not produce as much effect as the traditional hard start kit and so its use has generally been limited to smaller motors.

Potential Relay/Start Capacitor Connected as Hard Start Kit



NOTE: A problem may arise when a motor is equipped with a start capacitor and potential relay. The contacts of a potential relay are normally closed and open to drop the start capacitor from the circuit when the motor reaches about 3/4 rated speed. When the contacts open, the capacitor can be left in a charged condition and the charge will bleed off internally in several minutes while the motor runs. However, if for some reason, power is interrupted soon after starting, the capacitor will not have time to equalize. The relay contacts will close immediately and the full surge of the capacitor will be discharged across the contacts. Repeated instances like this will cause the relay contacts to pit and burn and lead to the premature failure of the relay.

The remedy is to install a bleed resistor across the capacitor terminals. This resistor, usually 15,000 to 18,000 OHMS, de-energizes the capacitor in seconds after the contacts open.

6. *USE THE CHART ON PAGE 11 TO TROUBLE SHOOT CAPACITORS:*

When a defective start capacitor is found, always check for the cause of failure. It could be that the failure was normal, due to age. The replacement capacitor can then be expected to restore the motor to satisfactory operation with no further problems.

Another cause of start capacitor failure may be a defective starting switch or relay holding the capacitor in the circuit too long. Start capacitors are designed for intermittent duty only and excessively long start periods can lead to premature failure. Also, the unit may be cycling too frequently. The general standard is for no more than 20 starts per hour or the capacitor will deteriorate.

Either of these last two conditions will cause the replacement capacitor to also fail in a short time. Always look for the ***cause*** of capacitor failure to avoid call backs.

Trouble Shooting Run Capacitors:
A shorted run capacitor has the effect of keeping the start winding in the circuit at all times. The motor typically draws high amperage, runs hot and may cycle on overload. It will run at about 3/4 speed. To check, disconnect one side of the capacitor while the motor is running, taking care to avoid electrical shock. If the speed increases and the motor appears to run as normal, the capacitor is shorted and must be replaced.

With a multiple capacitor hook-up, testing for shorted capacitor is the same for parallel or series connection. In parallel, if one shorts, the total capacitance of the system is decreased and the motor will start slowly. In series, if one shorts, the capacitance increases but the voltage capability of the circuit decreases and, as a result, the remaining capacitor soon fails.

An alternate test for a shorted run capacitor is with an OHM meter. A shorted capacitor will register zero resistance.

An open run capacitor may have little apparent effect on the motor, which will appear to run near normal performance. To test, disconnect one side of the capacitor and start the motor. Take a reading of the current drawn with an ammeter. Now connect the capacitor. If the capacitor is good, the amps should drop. If there is no change in amperage, the capacitor is defective and must be replaced.

CAUTION: When working with capacitors, always remember that they store an electrical charge. To prevent electrical shock, never assume that a capacitor is discharged until you have manually discharged it. This can be done by touching both terminals with the blade of a screwdriver having an insulated handle. This sudden surge of electrons can, however, sometimes in itself damage the capacitor. A better way is to have a bleed resistor connected to insulated leads and use this to jump the terminals. Use a 15,000 OHM resistor for starts and a 220,000 OHM resistor for runs.

7. *CAPACITOR TESTING EQUIPMENT:*

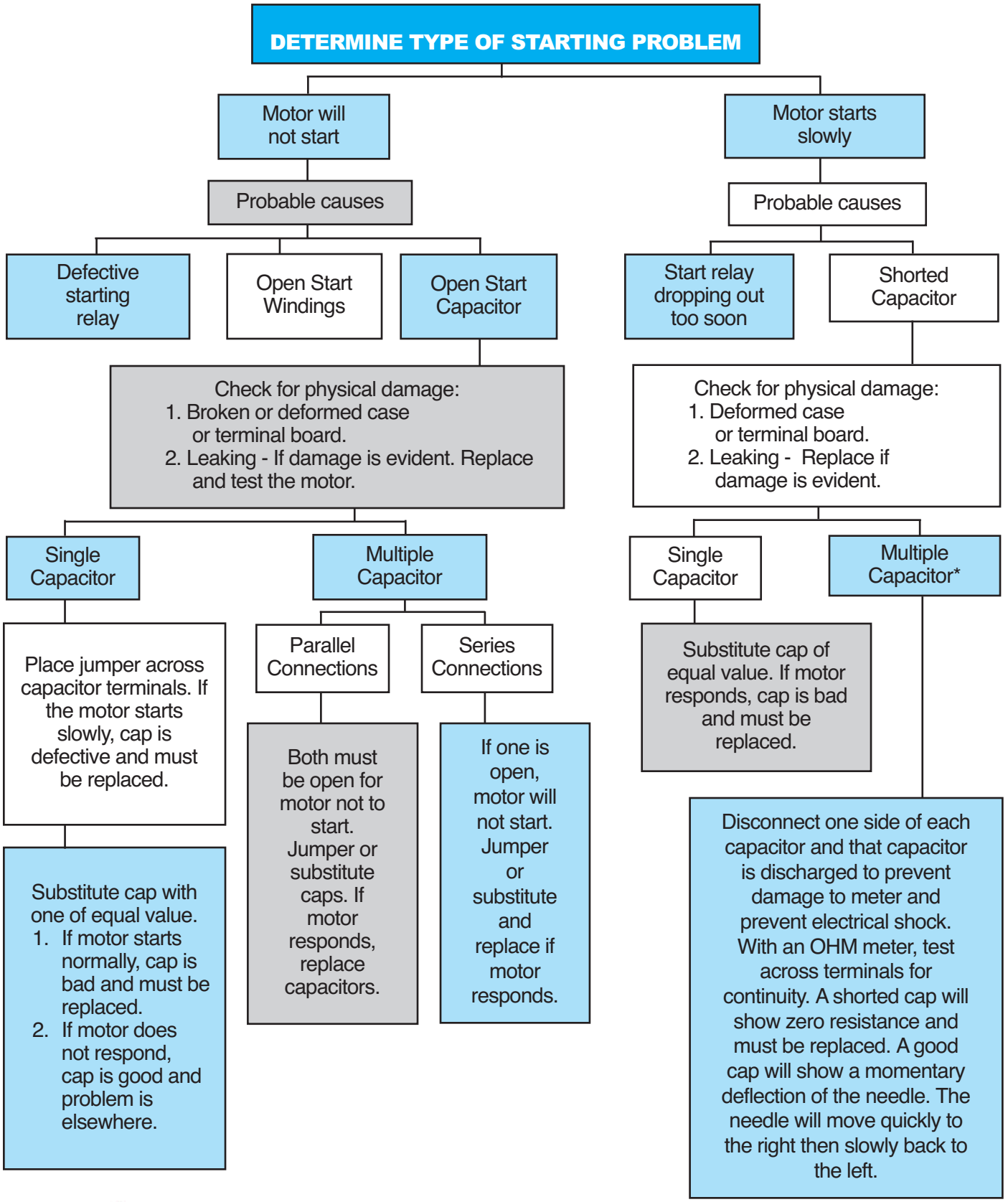
There are a number of devices available for testing and evaluating capacitors. Some are relatively inexpensive and indicate only whether the capacitor is open, shorted, or good.

More expensive units can be purchased which will tell you the mfd rating of a good capacitor if that information is not on the unit. Your local parts wholesaler sells these devices and a technician who services equipment with capacitors should consult with him to determine which test device best serves his needs.

8. *CONCLUSION:*

Capacitors are devices for storing electrons. They are used to increase the starting torque and power factor of electric motors. Replacements must be made with care to insure the correct type and rating (mfd and voltage) for each application. Two or more can be connected in parallel or series to arrive at different ratings. Trouble shooting should be done in a logical sequence to insure the proper identification of the defective part.

Capacitor Trouble - Shooting
Flow Chart



Blue Box RUN CAPACITORS

SINGLE SECTION

370 Volt Oval

MARS No.	Microfarad
12002	2
12003	3
12004	4
12005	5
12006	6
12007	7.5
12008	10
12009	12.5
12010	15
12012	17.5
12014	20
12015	25
12017	30
12018	35
12021	40
12023	45
12025	50
12024	55
12087	60
12011	65
12089	70
12090	80

440 Volt Oval

MARS No.	Microfarad
12026	2
12019	2.5
12027	3
12028	4
12029	5
12030	6
12031	7.5
12032	10
12033	12.5
12034	15
12036	17.5
12037	20
12040	25
12041	30
12043	35
12045	40
12048	45
12049	50
12050	55
12051	60
12052	65
12130	70
12135	75
12140	80

370 Volt Round

MARS No.	Microfarad
12092	2
12093	3
12094	4
12095	5
12096	6
12097	7.5
12098	10
12099	12.5
12210	15
12211	16
12212	17.5
12214	20
12215	25
12217	30
12218	35
12221	40
12223	45
12225	50
12226	55
12227	60
12128	65
12229	70
12199	80
12116	100

440 Volt Round

MARS No.	Microfarad
12102	2
12103	3
12104	4
12105	5
12106	6
12107	7.5
12232	10
12233	12.5
12234	15
12236	17.5
12237	20
12240	25
12241	30
12243	35
12245	40
12248	45
12251	50
12252	55
12254	60
12258	70
12259	80
12068	90

DUAL SECTION

370 Volt Oval

MARS No.	Microfarad
12141	15/3
12056	15/4
12057	15/5
12058	15/10
12059	17.5/4
12060	17.5/5
12061	20/3
12062	20/4
12063	20/5
12064	20/10
12164	20/15
12142	25/3
12065	25/4
12066	25/5
12143	25/7.5
12131	25/8
12167	25/10
12133	25/15
12144	30/3
12145	30/4
12069	30/5
12146	30/7.5
12147	30/10
12148	35/3
12071	35/4
12072	35/5
12149	35/7.5
12150	35/10
12151	40/3
12158	40/4
12171	40/5
12152	40/7.5
12134	40/10
12173	45/3
12174	45/5
12153	45/7.5
12136	45/10
12137	45/15
12138	50/5
12154	55/5
12155	55/7.5
12139	60/5
12156	60/7.5
12157	60/10
12159	65/5
12163	80/5
12123	80/7.5

440 Volt Oval

MARS No.	Microfarad
12165	10/5
12270	15/4
12271	15/5
12177	15/10
12180	20/5
12083	20/15
12184	25/5
12182	25/7.5
12183	25/10
12186	25/15
12181	30/4
12187	30/5
12038	30/7.5
12035	30/10
12085	35/3
12179	35/4
12185	35/5
12188	35/7.5
12176	35/8.5
12272	35/10
12080	40/3
12086	40/5
12189	40/7.5
12273	40/10
12190	45/5
12274	45/7.5
12108	50/5
12013	50/7.5
12275	55/5
12276	55/10
12109	60/5
12110	60/7.5
12101	65/10
12297	80/5
12298	80/7.5

370 Volt Round

MARS No.	Microfarad
12121	15/3
12122	15/4
12203	15/5
12204	15/10
12205	17.5/4
12206	17.5/5
12207	20/4
12260	20/5
12016	20/7.5
12208	20/10
12209	20/15
12242	25/3
12175	25/4
12261	25/5
12262	25/7.5
12213	25/10
12244	30/3
12263	30/4
12264	30/5
12224	30/7.5
12228	30/10
12039	30/15
12082	35/3
12231	35/4
12266	35/5
12235	35/7.5
12238	35/10
12074	40/3
12267	40/4
12178	40/5
12268	40/7.5
12246	40/10
12073	45/3
12247	45/4
12269	45/5
12249	45/7.5
12250	45/10
12075	50/3
12191	50/5
12192	50/7.5
12239	50/10
12193	55/5
12194	55/7.5
12067	55/10
12076	60/3
12195	60/5
12196	60/7.5
12265	60/10
12042	65/5
12053	70/5
12054	70/7.5
12055	70/10
12044	75/5
12046	75/7.5
12084	75/10
12197	80/5
12198	80/7.5
12201	80/10
12202	80/12.5
12129	85/5
12230	85/7.5
12222	85/10

440 Volt Round

MARS No.	Microfarad
12111	10/5
12118	15/5
12356	15/10
12350	17.5/5
12115	20/5
12354	20/7.5
12351	20/10
12112	20/15
12353	25/3
12355	25/4
12278	25/5
12279	25/7.5
12113	25/10
12114	25/15
12126	30/3
12120	30/4
12281	30/5
12282	30/7.5
12352	30/10
12077	35/3
12070	35/4
12283	35/5
12119	35/6
12284	35/7.5
12091	35/10
12078	40/3
12285	40/4
12286	40/5
12220	40/6
12287	40/7.5
12088	40/10
12079	45/3
12219	45/4
12288	45/5
12127	45/6
12289	45/7.5
12172	45/10
12290	50/5
12291	50/7.5
12124	50/10
12253	50/12.5
12292	55/5
12293	55/7.5
12299	55/10
12160	60/3
12294	60/5
12295	60/7.5
12296	60/10
12161	60/12.5
12162	65/10
12255	70/5
12166	70/7.5
12169	70/10
12168	75/5
12125	75/7.5
12047	75/10
12257	80/5
12216	80/7.5
12117	80/10
12022	85/5
12020	85/7.5
12001	85/10

JARD by MARS RUN CAPACITORS

SINGLE SECTION

370 Volt Oval

MARS No.	Microfarad
12902	2
12903	3
12904	4
12905	5
12906	6
12907	7.5
12908	10
12909	12.5
12910	15
12912	17.5
12914	20
12915	25
12917	30
12918	35
12921	40
12923	45
12925	50
12924	55
12987	60
12988	65
12989	70
12990	80

440 Volt Oval

MARS No.	Microfarad
12926	2
12919	2.5
12927	3
12928	4
12929	5
12930	6
12931	7.5
12932	10
12933	12.5
12934	15
12936	17.5
12937	20
12940	25
12941	30
12943	35
12945	40
12948	45
12949	50
12950	55
12951	60
12952	65
12830	70
12831	75
12840	80

370 Volt Round

MARS No.	Microfarad
12992	2
12993	3
12994	4
12995	5
12996	6
12997	7.5
12998	10
12999	12.5
12710	15
12911	16
12712	17.5
12714	20
12715	25
12717	30
12718	35
12721	40
12723	45
12725	50
12726	55
12727	60
12828	65
12729	70
12899	80
12916	100

440 Volt Round

MARS No.	Microfarad
12802	2
12803	3
12804	4
12805	5
12806	6
12807	7.5
12732	10
12733	12.5
12734	15
12736	17.5
12737	20
12740	25
12741	30
12743	35
12745	40
12748	45
12751	50
12752	55
12754	60
12758	70
12759	80
12868	90

DUAL SECTION

370 Volt Oval

MARS No.	Microfarad
12841	15/3
12956	15/4
12957	15/5
12958	15/10
12959	17.5/4
12960	17.5/5
12961	20/3
12962	20/4
12963	20/5
12864	20/10
12964	20/15
12842	25/3
12965	25/4
12966	25/5
12843	25/7.5
12832	25/8
12867	25/10
12833	25/15
12844	30/3
12845	30/4
12969	30/5
12846	30/7.5
12847	30/10
12848	35/3
12971	35/4
12972	35/5
12849	35/7.5
12850	35/10
12851	40/3
12858	40/4
12871	40/5
12852	40/7.5
12834	40/10
12874	45/5
12853	45/7.5
12836	45/10
12837	45/15
12838	50/5
12854	55/5
12855	55/7.5
12839	60/5
12856	60/7.5
12857	60/10
12859	65/5
12863	80/5
12817	80/7.5

440 Volt Oval

MARS No.	Microfarad
12765	10/5
12770	15/4
12771	15/5
12777	15/10
12880	20/5
12983	20/15
12884	25/5
12882	25/7.5
12883	25/10
12886	25/15
12881	30/4
12887	30/5
12982	30/7.5
12835	30/10
12985	35/3
12879	35/4
12885	35/5
12888	35/7.5
12876	35/8.5
12772	35/10
12877	40/3
12986	40/5
12889	40/7.5
12773	40/10
12890	45/5
12774	45/7.5
12808	50/5
12913	50/7.5
12775	55/5
12822	55/10
12809	60/5
12776	60/7.5
12810	65/10
12815	80/5
12898	80/7.5

370 Volt Round

MARS No.	Microfarad
12701	15/3
12702	15/4
12703	15/5
12704	15/10
12705	17.5/4
12706	17.5/5
12707	20/4
12760	20/5
12716	20/7.5
12708	20/10
12709	20/15
12711	25/3
12875	25/4
12761	25/5
12762	25/7.5
12713	25/10
12720	30/3
12763	30/4
12764	30/5
12724	30/7.5
12728	30/10
12939	30/15
12730	35/3
12731	35/4
12766	35/5
12735	35/7.5
12738	35/10
12739	40/3
12767	40/4
12878	40/5
12768	40/7.5
12746	40/10
12747	45/3
12947	45/4
12769	45/5
12749	45/7.5
12750	45/10
12753	50/3
12755	50/5
12825	50/7.5
12757	50/10
12893	55/5
12894	55/7.5
12967	55/10
12976	60/3
12895	60/5
12896	60/7.5
12865	60/10
12742	65/5
12953	70/5
12954	70/7.5
12955	70/10
12744	75/5
12946	75/7.5
12984	75/10
12897	80/5
12819	80/7.5
12824	80/10
12722	80/12.5
12829	85/5
12756	85/7.5
12922	85/10

440 Volt Round

MARS No.	Microfarad
12811	10/5
12818	15/5
12656	15/10
12650	17.5/5
12780	20/5
12654	20/7.5
12651	20/10
12812	20/15
12653	25/3
12655	25/4
12778	25/5
12779	25/7.5
12813	25/10
12814	25/15
12826	30/3
12820	30/4
12781	30/5
12782	30/7.5
12652	30/10
12977	35/3
12870	35/4
12783	35/5
12784	35/7.5
12797	35/10
12978	40/3
12785	40/4
12786	40/5
12920	40/6
12787	40/7.5
12798	40/10
12979	45/3
12891	45/4
12788	45/5
12827	45/6
12789	45/7.5
12872	45/10
12790	50/5
12791	50/7.5
12892	50/10
12719	50/12.5
12792	55/5
12793	55/7.5
12799	55/10
12860	60/3
12794	60/5
12795	60/7.5
12796	60/10
12861	60/12.5
12862	65/10
12823	70/5
12866	70/7.5
12869	70/10
12968	75/5
12901	75/7.5
12935	75/10
12801	80/5
12816	80/7.5
12821	80/10
12938	85/5
12942	85/7.5
12944	85/10

START CAPACITORS

MARS Blue Box

SINGLE SECTION

165 Volts AC		330 Volts AC	
MARS No.	Microfarad	MARS No.	Microfarad
11075	72-88	11055	21-25
11076	88-108	11056	25-30
11077	108-130	11057	30-36
11031	124-149	11058	36-43
11032	145-175	11059	43-56
11033	161-193	11060	56-72
11034	189-227	11160	64-77
11078	216-259	11061	72-88
11035	233-292	11062	88-108
11036	270-324	11063	108-130
11079	340-408	11064	130-156
11080	378-455	11165	124-156
11037	400-480	11092	135-162
11081	540-648	11066	145-175
11082	710-850	11067	161-193
11083	810-972	11068	189-227
		11069	216-259
		11070	270-324
		11093	300-360

DUAL SECTION

110/125 Dual Voltage AC		220/250 Dual Voltage AC	
MARS No.	Microfarad	MARS No.	Microfarad
11002	21-25	11038	21-25
11003	25-30	11039	25-30
11004	30-36	11040	30-36
11005	36-43	11041	36-43
11006	43-56	11042	43-56
11007	56-72	11043	56-72
11008	72-88	11084	59-71
11009	88-108	11137	64-77
11010	108-130	11044	72-88
11112	124-156	11045	88-108
11011	130-156	11046	108-130
11013	145-175	11148	124-156
11014	161-193	11049	145-175
11015	189-227	11050	161-193
11016	200-240	11051	189-227
11017	216-259	11052	216-259
11018	233-292	11053	233-292
11019	270-324	11054	270-324
11020	300-360	11085	280-336
11021	324-388	11086	320-384
11022	340-408	11087	340-408
11023	378-440	11088	378-455
11024	400-480	11089	400-480
11071	430-516	11090	430-516
11025	460-552	11091	630-750
11026	540-648		
11027	590-708		
11047	645-774		
11028	708-850		
11072	815-970		
11029	829-995		
11073	850-1020		
11030	1000-1200		
11074	1290-1548		

JARD by MARS

SINGLE SECTION

165 Volts AC		330 Volts AC	
MARS No.	Microfarad	MARS No.	Microfarad
11975	72-88	11955	21-25
11976	88-108	11956	25-30
11977	108-130	11957	30-36
11931	124-149	11958	36-43
11932	145-175	11959	43-56
11933	161-193	11995	56-72
11934	189-227	11960	64-77
11978	216-259	11961	72-88
11935	233-292	11962	88-108
11936	270-324	11963	108-130
11979	340-408	11964	130-156
11980	378-455	11965	124-156
11994	400-480	11992	135-162
11981	540-648	11966	145-175
11982	710-850	11967	161-193
11983	810-972	11968	189-227
		11969	216-259
		11970	270-324
		11993	300-360

DUAL SECTION

110/125 Dual Voltage AC		220/250 Dual Voltage AC	
MARS No.	Microfarad	MARS No.	Microfarad
11902	21-25	11938	21-25
11903	25-30	11939	25-30
11904	30-36	11940	30-36
11905	36-43	11941	36-43
11906	43-56	11942	43-56
11907	56-72	11943	56-72
11908	72-88	11984	59-71
11909	88-108	11937	64-77
11910	108-130	11944	72-88
11912	124-156	11945	88-108
11911	130-156	11946	108-130
11913	145-175	11948	124-156
11914	161-193	11949	145-175
11915	189-227	11950	161-193
11916	200-240	11951	189-227
11917	216-259	11952	216-259
11918	233-292	11953	233-292
11919	270-324	11954	270-324
11920	300-360	11985	280-336
11921	324-388	11986	320-384
11922	340-408	11987	340-408
11923	378-440	11988	378-455
11924	400-480	11989	400-480
11971	430-516	11990	430-516
11925	460-552	11991	630-750
11926	540-648		
11927	590-708		
11947	645-774		
11928	708-850		
11972	815-970		
11929	829-995		
11973	850-1020		
11930	1000-1200		
11974	1290-1548		

TURBO® 200 Universal Run & Start Capacitor Replacement

One model covers a range of single and dual mfd ratings.

MARS #	Description	Microfarad
12100	TURBO® 200 mini	2.5 mfd - 12.5 mfd, 370V or 440V
12200	TURBO® 200	2.5 mfd - 67.5 mfd, 370V or 440V
12300	TURBO® 200 X	5.0 mfd - 97.5 mfd, 370V or 440V
11200	Turbolytic™ 50 Universal Motor Start Capacitor	23 mfd - 302 mfd, 125V to 330V
11100	Turbolytic™ JR	23 mfd - 208 mfd, 125V to 330V

The Real Deal!

Don't Risk Customer Complaints and Callbacks Resulting From Inferior Capacitors!

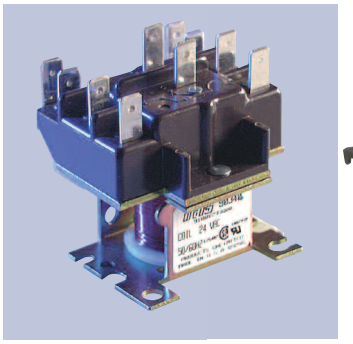
MARS RUN CAPACITORS MEET OR EXCEED THE FOLLOWING SPECIFICATIONS:

- Meet the EIA 456 standard. This life test is 125% of rated voltage at 80˚C for 2,000 hours. This life test equates to 60,000 hours at rated voltage and rated temperature.
- Meet the Tecumseh H115 standard, tested at 135% of rated voltage at 10˚C above rated temperature for 500 hours.
- VDE approved. VDE is tested according to the British Standard, which permits MARS to mark capacitors with CE approval.
- Tested and approved by every major U.S. motor company and compressor company.
- CSA approved and UL recognized.

For "The Real Deal"

ASK FOR MARS RUN CAPACITORS IN THE BLUE BOX

Why Choose MARS?



The Leading Brands You Trust For...

- Quality
- Innovation
- Design
- Leadership

MARS has been serving the HVAC/R market since 1946 and is proud to present the most complete motor and accessory product offering to serve your needs. Our capabilities include:

- Consolidation - One Stop Shop
- Over 14,000 combinable products
- Value-added sales support and services
- Industry leading brands
- Award winning distribution facilities
- +97% order fill rate
- Billing accuracy
- Bilingual Website
- Training Focused
- EDI capabilities

Thank you for your business !

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