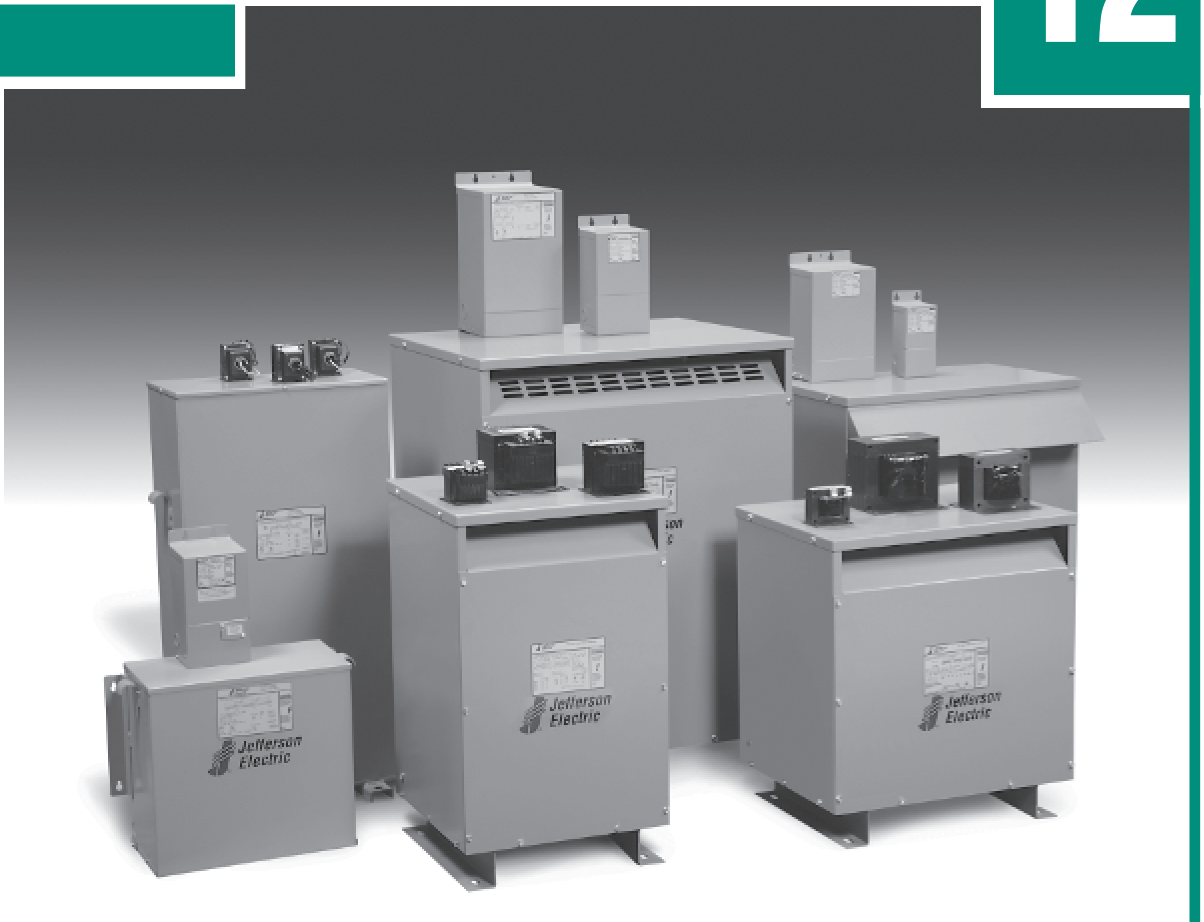
12



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Installation

Carefully inspect the transformer before signing the delivery receipt. Any damage should be noted on the receipt and a claim placed against the transportation company. Protective grease placed on terminal connections should not be removed. The grease is a protective coating that prevents the oxidation of the conductor. Bolt the terminal connector firmly to the bus bar, allowing the protective film to be forced out.

Safety

Transformers are provided with access covers to facilitate installation and service. They must be kept securely in place at all times when the transformer is operating.

CAUTION: *Normal operating voltages can be extremely hazardous. Only qualified personnel should install, inspect or service transformers. Disconnect the power before opening the cover or touching any internal parts.*

Storage

Transformers should be stored in a warm, dry location of uniform temperature and in their original packing. If the transformer has been unpacked, all ventilating openings should be covered to keep out dust. Outdoor storage should be avoided, but if this is not possible, the transformer must be protected against moisture and contaminants.

Condensation and moisture can be reduced with heaters. If the transformer has been subjected to moisture, it should be baked out before energizing. This is especially important in transformers of 5 KV or higher.

Taps

If the transformer comes supplied with taps, they will generally have a full capacity rating. A common tap arrangement is two 2.5% taps above FCAN and four 2.5% taps below FCBN nominal voltage. Transformers are shipped with the taps connected for nominal voltage, that is, 480 volts for a 480 volt transformer. The installing electrician must change the taps if the supply voltage differs from the nominal voltage rating.

Connections and Circuits

The transformer should be connected only as described on the nameplate or the wiring diagram inside the wiring compartment cover, or as otherwise specifically authorized by Jefferson Electric.

Transformers without terminal boards, usually the smaller size transformers, provide leads for connections.

IMPORTANT: *Any unused taps or leads must be insulated from each other and taped*

Encapsulated transformers, 2 KVA and smaller, have their turns ratio compensated for losses so that their open circuit voltage is somewhat higher than the load voltage. Machine tool transformers are compensated up to 5 KVA. Using transformers in the reverse direction from which it is designed would result in lower than expected output voltage.

Mounting and Spacing

Dry-type transformers depend on air for cooling, and must be placed so that room air can circulate freely around them. Cabinet style transformers must be mounted so that air can pass freely through the ventilation openings. The transformer space should be kept clear.

Transformers should be spaced at least six inches apart. Transformers rated 30 KVA and larger should be kept at least six inches from walls and ceilings.

Transformers should never be mounted near heat-generating equipment or near heat-sensitive equipment. Transformers should never be placed in a room with hazardous processes, or where flammable gasses or combustible materials are present. Particular care must be taken when mounting in unventilated plenums or in closets with no ventilation. In areas without free moving air, ambient temperatures can rise above acceptable limits, causing the transformer to overheat.

Maintenance

Periodic inspection of the transformer should be made, depending on conditions. In most clean, dry installations, once a year is usually sufficient.

After disconnecting the transformer from the power, the cover should be removed and any dirt cleaned out. Screens covering the ventilating openings should be cleaned.

Inspect for loose connections, terminal and splice conditions and for signs of overheating, rust or deteriorating paint.

NEMA Transformer Enclosure Definitions

Type 1	General purpose – indoor.
Type 2	Drip-proof – indoor.
Type 3	Wind blown dust and water – indoor/outdoor.
Type 3R	Rainproof and sleet/ice resistant – outdoor. Meets above type requirements.
Type 3S	Dust-tight, rain-tight, and sleet/ice proof – outdoor.
Type 4	Water-tight and dust-tight – indoor/outdoor.
Type 4X	Water-tight, dust-tight and corrosion resistant – outdoor.
Type 5	Dust-tight – indoor.
Type 6	Submersible, water-tight, dust-tight and sleet/ice resistant – indoor/outdoor.
Type 7	Class I, Group (S) A,B,C and/or D – indoor hazardous locations - air-break equipment.
Type 8	Class I, Group (S) A,B,C and/or D – indoor hazardous locations.
Type 9	Class II, Group (S) E,F and/or D – indoor hazardous locations - air-break equipment.
Type 10	Bureau of Mines.
Type 11	Drip-proof and corrosion resistant.
Type 12	Industrial use dust-tight and drip-tight – indoor.
Type 13	Oil-tight and dust-tight – indoor.

Source: NEMA Pub. No. ST20.

Recommended Copper Wire and Transformer Size

HP	Transformer KVA	Distance - Motor to Transformer in Feet				
		100	150	200	300	500
Single-Phase Motors - 230 Volts						
1½	3	10	8	8	6	4
2	3	10	8	8	6	4
3	5	8	8	6	4	2
5	7½	6	4	4	2	0
7½	10	6	4	3	1	0

HP	Volts	Transformer KVA	Distance - Motor to Transformer in Feet				
			100	150	200	300	500
Three-Phase Motors - 230 & 460 Volts							
1½	230	3	12	12	12	12	10
1½	460	3	12	12	12	12	12
2	230	3	12	12	12	10	8
2	460	3	12	12	12	12	12
3	230	5	12	10	10	8	6
3	460	5	12	12	12	12	10
5	230	7½	10	8	8	6	4
5	460	7½	12	12	12	10	8
7½	230	10	8	6	6	4	2
7½	460	10	12	12	12	10	8
10	230	15	6	4	4	4	1
10	460	15	12	12	12	10	8
15	230	20	4	4	4	2	0
15	460	20	12	10	10	8	6
20	230	Consult Local Power Company	4	2	2	1	000
20	460		10	8	8	6	4
25	230		2	2	2	0	000
25	460		8	8	6	6	4
30	230		2	1	1	00	0000
30	460		8	6	6	4	2
40	230		1	0	00	0000	300
40	460		6	6	4	2	0
50	230		1	0	00	0000	300
50	460		4	4	2	2	0
60	230		1	00	000	250	500
60	460		4	2	2	0	00
75	230		0	000	0000	300	500
75	460		4	2	0	00	000

Source: EASA Handbook.

Protective Equipment

The importance of protecting your power delivery system cannot be overstated. The system must be protected against short circuits, surges caused by lightning, switching and overheating. Equipment is available to provide this protection, but it must also be adequately sized and properly installed. Failure to do so could damage the transformer and invalidate its warranty.

Protective equipment includes circuit breakers and fuses.

The selection and placement of protective equipment within the system is the responsibility of the end user.

Circuit Breakers

When any component of a circuit fails, there is nothing to limit current flow except the resistance of the circuit conductors and the resistance of the fault itself. The currents in these situations can be extremely large and destructive, making it imperative to interrupt the circuit as quickly as possible.

Circuit breakers are designed to react to a fault by making a physical separation in the current-carrying or conducting element by inserting an insulating medium. Breakers come in different types, depending on the insulating medium used. While the most common insulation is oil, air is used in some 600 Volt class circuits. For higher voltages and larger capacities, the insulating medium might be a vacuum or and inert gas such as sulphur hexafluoride.

Specifications for a circuit breaker will depend on the operating voltage of the circuit, the normal operating or maximum load current, and the maximum abnormal or fault current to be interrupted. Circuit breakers are rated in KVA or MVA and express the ability of the breaker to withstand short circuit forces.

Circuit breakers must withstand large inrush currents that result when voltage is initially switched on. These currents can be 20 to 30 times the rated transformer current even with no-load. Therefore, breakers must have built-in time delay for the first 5 to 10 cycles to avoid tripping under "turn-on" currents.

Fuses

The most common protective device in use, the fuse is basically a circuit breaker that works only once and then must be replaced. When current exceeds the predetermined current value, a fusible link melts, opening the circuit.

When voltage is initially switched on, a large inrush current results, being greatest in the first half-cycle of operation, or approximately .01 second. This current becomes less severe over the next few cycles, or approximately .1 second until the transformer is operating normally. Because of inrush current, fuses are often selected to withstand as much as 25 times primary rated current for .01 second, and 12 times primary rated current for .1 second.

Fuse Selection

The tables provide guidance for selecting fuses when the maximum voltage in the circuit is 600 Volts or less. These tables are included in Article 450-3 of the National Electrical Code covering over-current protection of transformers.

If primary protection only is required, use Table 1. If both primary and secondary protection are required, refer to Table 2.

IMPORTANT: *These tables are to be used as a guide only. The final determination of application is the responsibility of the end user.*

Primary Fuse Only - Table 1

Transformer Primary Amperes	Maximum Primary Fuse % Rating
9 or More	125*
2 or 9	167
Less than 2	300

**If 125% does not correspond to a standard ampere rating, the next higher standard rating described in NEC Article 240-6 shall be permitted.*

Primary and Secondary Fuses - Table 2

Transformer Secondary Amperes	Maximum % Rating	
	Primary Fuse	Secondary Fuse
9 or More	250	125*
Less than 9	250	167

Primary Fuse Selection

Primary fuse selection is made according to rated primary current (Ipri). To determine Ipri, the transformer rating (VA or KVA) and primary voltage (Vpri) must be known as well as whether the transformer is single- or three-phase. With this information, use the appropriate formula to determine Ipri.

Once Ipri is known, select fuses according to Table 1 or 2 above.

Secondary Fuse Selection

Secondary fuse selection is made according to rated secondary current (Isec). To determine Isec, the transformer rating (VA or KVA) and secondary voltage (Vsec) must be known as well as whether the transformer is single- or three-phase. With this information, use the appropriate formula to determine Isec.

Once Isec is known, select fuses according to Table 2 above.

Primary Fuse Formulas

Single-Phase Transformers

$$Ipri = \frac{\text{Transformer VA}}{\text{Vpri}}$$

OR

$$Ipri = \frac{\text{Transformer VA}}{\text{Vpri}} \times 1000$$

Three-Phase Transformers

$$Ipri = \frac{\text{Transformer VA}}{1.73 \times \text{Vpri}} \times 1000$$

Secondary Fuse Formulas

Single-Phase Transformers

$$Isec = \frac{\text{Transformer VA}}{\text{Vsec}}$$

OR

$$Isec = \frac{\text{Transformer VA}}{\text{Vsec}} \times 1000$$

Three-Phase Transformers

$$Isec = \frac{\text{Transformer VA}}{1.73 \times \text{Vsec}} \times 1000$$

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Insulation and Temperature

All Jefferson Electric transformers are designed and manufactured with the best quality insulation available. There are classes of insulation systems for different temperatures as defined by NEMA and ANSI. Insulation classes are rated in °C rise above a specific ambient of 40°C maximum. A transformer having a specific class of insulation, for example Class 220, can have an average winding temperature rise of 150°C with a maximum hot spot temperature rise of 180°C. If the room ambient temperature is 40°C, then the total temperature of the hottest spot would be 220°C. Jefferson Electric transformers are designed to operate at rated load and voltage in maximum room ambient temperatures of 40°C, average room ambient temperature not to exceed 30°C, and at altitudes not to exceed 3300 feet in accordance with NEMA standards.

Insulating Classifications

The designations for insulation systems are numerical classifications based on temperature ratings. Transformer ratings are based on temperature rise. The accompanying table shows the designations.

Transformer and Insulation Systems Ratings

Ventilated

Insulation Class	Temperature Rise	Ambient Temperature	Hot Spot Allowance
105	55°C	40°C	10°C
150	80°C	40°C	30°C
180	110°C	40°C	30°C
220	150°C	40°C	30°C

Encapsulated

Insulation Class	Temperature Rise	Ambient Temperature	Hot Spot Allowance
105	70°C	25°C	10°C
130	95°C	25°C	10°C
180	135°C	25°C	20°C

Control Transformers

Insulation Class	Temperature Rise	Ambient Temperature	Hot Spot Allowance
105	55°C	40°C	10°C
130	80°C	40°C	10°C
155	100°C	40°C	15°C
180	120°C	40°C	20°C

Overloads

Overloads exceeding the maximum allowable insulation temperature can be tolerated, provided the overload is of short duration and is preceded and followed by a period of operation at less than rated KVA (refer to ANSI C57.96-1989, Tables 5,6,7). Overloading should be avoided unless approval is obtained from the Jefferson Electric engineering department.

High Ambient Temperatures

Ambient temperatures above 30°C average over a 24-hour period and 40°C maximum require either a larger KVA rating or a special low temperature rise transformer. A 150°C rise air cooled transformer can also be derated using the formula of .4% KVA reduction for each degree centigrade above 30°C ambient temperature.

Altitude Correction

For transformers above 3300 feet, reduce the KVA rating .3% for each 330 feet above 3300 feet.

Transformer Sound

Transformers, like other electromagnetic devices, produce a "hum" caused by the alternating flux in the transformer core. This "hum", known as magnetostriction, is primarily produced at a fundamental frequency of twice the applied frequency. The relative loudness depends on the construction of the transformer, the manner of installation and the ambient sound level at the site.

The sound produced by a transformer has a fundamental frequency of 120 Hz, accompanied by harmonics of 240, 360, 480, 600, etc.

Controlling Transformer Sound

Sound control becomes more important as power demands increase and transformers are placed closer to their loads. Planning of transformer placement and specification is especially important in designing high rise apartments, hospitals and office buildings.

Proper installation can significantly reduce transformer noise. For a quiet installation:

- Consult your architect about the location of the transformer while the building is being designed.
- Install the transformer as far as possible from areas where the sound could be objectionable.
- Avoid placing near multiple reflective surfaces such as in a corner, near a ceiling or floor, or in a hallway.
- Place sound-dampening pads between the transformer and the mounting surface. (Pads may be neoprene with sandwiched cork material or spring loaded with a rubber base.)
- Use flexible conduit couplings between the transformer and the wiring system.
- Mount the transformer on walls or structural members sufficient to support its weight.
- To avoid amplifying the sound, mount the transformer on a surface with as large a mass as possible.

Judge transformer sound only when the building is finished, occupied and functioning.

Sound Testing Standards

NEMA ST 1-4 (ANSI-C89.1) section 2.7 covers "Audible Sound Level Test." For a thorough understanding of these tests it should be read in its entirety.

Briefly, the transformer is tested at its rated frequency and voltage under no-load conditions in a room which is 10 feet larger on all sides than the transformer. The ambient sound level of the room must be at least 5 db, and preferably 10 db, below the ambient level plus the transformer level. Five sound readings are taken with an approved sound meter one foot from each side of the transformer enclosure and one foot above the enclosure. The sound rating is the average of these five readings.

For three-phase transformers, the NEMA maximum allowable averages of the readings in decibels are shown in the chart below.

Transformer NEMA Maximum Single and Three-Phase db Ratings

KVA Rating	600V Class
0 - 9	40
10 - 50	45
51 - 150	50
151 - 300	55
301 - 500	60
501 - 700	62
701 - 1000	64

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Condition	Possible Cause	Suggested Remedy
Hot transformer	High ambient temperature	Improve ventilation or relocate unit to cooler location.
	Overload	Reduce load; reduce amperes by improving power factor with capacitors; check for circulating currents for paralleled transformers - different ratios or impedances; check for open phase in delta bank.
	High voltage	Change circuit voltage, taps.
	Insufficient cooling	If other than naturally cooled, check fans, pumps, valves and other units in cooling systems.
	Winding failure – incipient fault	See "No voltage - unsteady voltage" below.
	Short-circuited core	Test for exciting current and no-load loss; if high, inspect core, remove and repair; check core bolt, clamps and tighten; check insulation between laminations; if welded together, return to factory for repair or replacement.
	High harmonic loads	Measure neutral current - replace with K-rated transformer
Noisy transformer	Overload	See "Hot transformer" above.
	Metal part ungrounded, loose connection	Determine part and reason; check clamps, cores and parts normally grounded for loose or broken connections, missing bolts or nuts, etc.; tighten loose clamps, bolts, nuts; replace missing ones.
	External parts and accessories in resonant vibration	Tighten items as above; in some cases, loosen to relieve pressure causing resonance and install shims.
	Incipient fault – core or winding	See above under "Hot transformer."
No voltage – unsteady voltage	Winding failure - lightning; overload; short-circuit from foreign object or low strength dielectric	Check winding; remove foreign object or damaged material; repair or replace parts of insulation materials.
Rust and paint deterioration	Weather, pollution, corrosive or salt atmosphere; overloads	Remove rust and deteriorated paint; clean surfaces; repaint with proper paints and sufficient coatings.
	Excessive heating discoloration	If excessive heating discoloration occurs, check sizing, input voltage, or loading amps.

Condition	Possible Cause	Suggested Remedy
Hot neutral line	Overload	Too small neutral conductor: replace. Severe unbalance between phase: rebalance and equalize loads.
	One leg of wye bank open	Check associated fuse. If blown, remove cause and replace. Check for open circuit in winding of transformer in bank. Measure odd harmonic amps with RMS meter.
Voltage unbalanced	Open neutral unbalanced loads	Check neutral connections. See "Hot neutral line" above.
Voltages high and unbalanced	Open neutral on wye bank ground in winding of one transformer in wye	Check neutral connections and load balance. Check values of voltages between phases and phase-to-ground voltages. Vector should indicate source of trouble.
No voltage – one phase of delta connected bank	Grounds on two legs of delta (delta collapse - loads "single phasing")	Remove grounds from at least one leg of delta source.
Overloads on two delta bank	Open in third transformer of bank; operating in open delta	Check fuses on supply to their bank; check winding of transformers in third transformer for continuity.
Low voltage on two phases of delta	Open in one phase of delta supply; two transformers now connected across one same phase	Check fuse on supply; check supply circuit back to source for open circuit.

Frequently Asked Questions
(See Also Glossary of Terms)

What will happen if transformers are operated at non-nameplate voltages?

A transformer is designed using specific ratios that relate to the rated KVA, primary voltage and secondary voltage proportionally. Operating a transformer above or below the nominally designed primary voltage will reflect a proportional increase or decrease in secondary output levels. Extreme caution must be observed when overvoltage levels exist. Excessive input voltage will cause higher core losses, increased noise and elevated temperatures. Overvoltages for any extended period of time have a significant effect on insulation breakdown and transformer failures. Transformers can be specifically designed for extreme voltage conditions if initial specifications state those requirements.

Can transformers be operated at different frequencies?

A 60 Hz design is physically smaller than a 50 Hz design. DO NOT use 60 Hz rated transformers on 50 Hz service. Without special designs, higher losses and greater heat rise will result. Operating 60 Hz transformers at higher frequencies may simply provide less voltage regulation.

Can transformers be used in parallel?

It is very common for transformers to be placed in parallel service. To provide maximum efficiency, voltage and impedance values must match closely for each transformer involved. A failure to match voltage and impedances will cause unbalanced loading for the transformers and may lead to overheating or premature failure.

What would be the result of overloading dry type transformers?

All Jefferson Electric transformers are designed to accommodate short periods of overloading. As the overload becomes excessive and the duration increases, the transformer will experience a percent loss of life.

Prolonged overloading generates excessive heating which results in insulation deterioration and ultimately transformer failure. Contact your Jefferson Electric application engineer to determine loading for your unique application.

What is meant by a transformer's temperature rise?

A transformer's rated temperature rise (degrees Celsius) is the average temperature of the transformer's windings over an ambient temperature of 40°C. In other words, the average winding temperature = ambient + temperature rise.

Why is the transformer case hot?

Transformers are designed to operate at a specific load. As transformers are overloaded, losses generated increase, resulting in a potential for case heating. If a transformer is properly sized for a specific application, no excessive heating should be present.

Why do transformers make a noise?

The hum is caused by alternating flux in the core and is known as magnetostriction. The humming can be minimized in manufacturing and through the use of dampening pads when installed.

Can I achieve specific sound levels in a transformer?

Whenever noise is a concern, but before selecting a transformer, assure yourself that the sound levels represented have been measured in accordance with the NEMA standards. If your requirement is lower than that available from the manufacturer's standard product, request a specific sound level on your RFQ or bid.

What about transformers in reverse?

Most transformers can be connected in reverse, to proper voltages, and will provide the voltages as specified on the nameplate. However special conditions apply to transformers rated 2KVA or less and for transformers rated 150 KVA or larger. Since smaller transformers (2KVA or less) are designed with compensation to ensure proper output voltage when connected normally. The output voltage may be less than expected when wired in reverse. Larger transformers (150 KVA or larger) may have a high in-rush current on startup that could trip a standard circuit breaker

CAUTION: *When connecting a Delta-Wye transformer in reverse the primary should be connected as a Delta (ignoring the X0 terminal). Connecting the X0 on the primary may cause unsafe conditions in fault situations.*

What type of terminations are provided on Jefferson Electric transformers?

Jefferson Electric dry type transformers are provided with the following primary and secondary terminations:

Encapsulated	wire leads
Ventilated	terminals
Machine Tool	terminals
Control	leads
Others	to order

Do Jefferson Electric transformers carry CSA certification?

Any Jefferson Electric transformer sold in Canada has been certified to the Canadian Standards Association's latest specifications. Units certified by the Canadian Standards Association are marked with the CSA logo. Those certified by Underwriter's Laboratory are marked with the C-UL logo

How do I determine the electrical load?

Obtain the following standard nameplate or instruction manual data for the equipment (the load) to be powered:

- Voltage required by the equipment
- Amperes or KVA capacity required by the equipment
- Required frequency of source voltage in Hz (cycles per second)
- Determine whether the load is designed to operate on a single- or three-phase supply

What is the supply voltage?

The supply voltage may be higher or lower than the voltage required by the load. However, the frequency of the two may not differ.

If your load ratings are not expressed in KVA, use the load voltage and amperage to determine the KVA.

For single-phase:	VA = volts x amperes
	KVA = VA/1000
For three-phase:	VA = volts x amperes x 1.73
	KVA = VA/1000

Once you have a KVA rating, then select a transformer from the charts in the appropriate section of this catalog by matching the primary and secondary voltages determined above.

What is an isolating transformer?

In an isolating transformer, the primary and secondary windings are connected magnetically, but not electrically. Also referred to as an "insulating" transformer.

Can I connect a single-phase transformer to a three-phase source?

Yes, and the transformer output will be single-phase. Simply connect any two wires from a 3- or 4-wire source to the transformer's two primary leads. Three single-phase transformers can be used for three-phase applications. They can be used in delta-connected primary and wye or delta-connected secondary. To avoid an unstable secondary voltage, NEVER connect wye primary to delta secondary.

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Can I use a transformer to change three-phase to single-phase?

It is not possible for a transformer to present a balanced load to the supply and deliver a single-phase output. Changing three-phase to two-phase, and vice-versa, can be done using special circuitry with standard dual-wound transformers.

What is voltage regulation in a transformer?

The voltage difference between loaded and unloaded output. To provide the proper secondary load voltage, extra primary windings cause the no-load secondary voltage to be 3-5% higher than the load voltage. Also known as "compensated windings."

How do I know when the temperature rise is too high?

Touch is a poor indicator of proper transformer operating temperature. Properly designed transformers can reach 50°C (122°F) above ambient temperature. In an ambient temperature of 20°C (60°F), the total temperature can reach 70°C (190°F), which is too hot to touch. Thermometers are the best way to determine the temperature.

Do I need special transformers for high ambient temperatures?

If you have an immediate need that cannot wait for a custom-built transformer, you can de-rate a standard transformer. For each 10°C above 30°C, de-rate the maximum loading by 4% (30°C = 100%; 40°C = 96%; 50°C = 92%; 60°C = 88%).

What is a non-linear (K-factor) transformer?

A transformer that is designed to handle the odd harmonic current loads caused by much of today's modern office equipment.

A non-linear transformer has a K-factor rating that is an index of its ability to supply harmonic content in its load current while remaining within its operating temperature limit.

What is a drive isolation transformer?

A drive isolation transformer is designed for use with motor drives. It must isolate the motor from the line and handle the added loads of the drive-created harmonic current. It is important to heed the drive manufacturer's recommendations for transformer KVA.

What is a buck-boost transformer?

Buck-boost transformers are single-phase isolated distribution transformers having four windings instead of two. They can be connected as an autotransformer to buck (reduce) or boost (raise) the line voltage from 5 - 20%. Typical reduced secondary voltages are 12, 16, 24, 32, or 48 volts. Commonly found raised secondary voltages are 208 to 230 or 240 volts.

Glossary

A

ANSI American National Standards Institute. A recognized body which approves standards for transformers. ANSI C 57.12 series contains the standards most often used for dry type transformers.

Air-Cooled A transformer cooled by the natural circulation of air over and/or through the core and coils.

Alternating Current (or voltage) Current that alternates regularly in direction, is periodic and has an average value (over a period of time) of zero.

Ambient Noise Level The existing or inherent sound level of the area surrounding a transformer installation. Measured in decibels.

Ambient Temperature The temperature of the air surrounding the transformer.

Ampacity The current-carrying capacity of an electrical conductor or device.

Ampere The practical unit of electric current.

Attenuation Decrease in signal voltage or power.

Autotransformer A transformer in which part of one winding is common to both the primary and the secondary circuits associated with that winding.

B

BIL Basic Insulation Level. A measure of the ability of the insulation system to withstand very high voltage surges. For example, a 600 volt class transformer has a 10 KV BIL rating.

Banked Two or more single-phase transformers connected together, or banked, to supply power. Three single-phase transformers banked together will produce a KVA capacity of three times the nameplate rating of the individual single-phase transformers. For example, three 5 KVA single-phase transformers connected together for a three-phase load will have a 15 KVA capacity.

C

CE Mark to indicate third party approved or self-certification to European Community requirements.

CSA Canadian Standards Association. The Canadian equivalent of Underwriter's Laboratories (UL).

CUL Mark to indicate UL certification to CSA standards.

Celsius Same as Centigrade. To convert Centigrade to Fahrenheit, use the following formula:
$°F = 1.8 \times °C + 32$.

Coil A number of turns of conductor wound as a coil.

Compensated Transformer A transformer with a turns ratio which provides a higher rated voltage at no-load and rated voltage at rated load. Normally used on units rated 2 KVA or smaller.

Continuous Duty The service requirement that demands operation at a constant load for an indefinite period of time.

Continuous Rating The load that a transformer can handle indefinitely without exceeding the specified temperature rise.

Control Transformer Usually referred to as an Industrial Control Transformer. Designed for good voltage regulation characteristics when low power factor and/or large inrush currents are drawn (5 to 15 times normal).

Conductor Losses Losses in the transformer winding that are incidental to the carrying of the load. These losses include those due to resistance as well as to stray and eddy currents.

Core The steel that carries the magnetic flux in a transformer.

Core Loss Losses caused by a magnetization of the core and its resistance to magnetic flux.

Cycle One complete sequence of values of an alternating quantity, including a rise to maximum in one direction, a return to zero, a rise to a maximum in the opposite direction, and a return to zero.

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D

Decibel (db) A unit used to express the magnitude of a change in signal or sound level, either an increase or a decrease.

Delta Connection A method used for connecting the three windings of a three-phase transformer (or three single-phase transformers). The windings are connected in series, the three-phase supply being taken from or supplied to the junctions.

Delta Wye The method of connection for both primary and secondary windings of a three-phase transformer bank.

Dielectric Tests A series of tests conducted at a much higher than rated nameplate voltage to assure the integrity of insulating materials and electrical clearances.

Distribution Transformer Any transformer rated between 3 and 500 KVA and a primary voltage of 601 volts or less.

Double Wound Transformer See Isolating Transformer.

Drive Isolation Transformer A transformer designed to withstand the additional heat and mechanical stress caused by DC drives.

Dry Type Transformer A transformer cooled by a medium other than a liquid, usually through the circulation of air.

Dual Winding A winding that consists of two separate windings which can be connected in series to handle a specific voltage and KVA or in parallel to handle the same KVA at one-half the series connected voltage.

E

Eddy Currents Additional currents caused by a time varying magnetic field.

Effective Voltage or Current 0.707 times the peak value of AC voltage or current. Effective value is also designated RMS value (Root Mean Square). When AC voltage is referred to, the effective value is understood unless otherwise noted. Symbols "E" and "I" without subscripts indicate effective values.

Efficiency The efficiency of a transformer is the ratio of its power output to its total power input.

Electrostatic Shield A grounded conductor placed between the primary and secondary winding to greatly reduce or eliminate line-to-line or line-to-ground noise. Often referred to as a "Faraday shield."

Excitation Current The steady rate current that keeps the transformer energized after the inrush has dissipated, with all other windings open-circuited. Also called "magnetizing" or "no-load current."

Exciting Wattage The no-load loss of a transformer.

F

FCAN and FCBN Taps Full Capacity Above Nominal and Full Capacity Below Nominal. The FCAN designation is used to indicate that a transformer will deliver rated KVA when connected to a voltage source which is higher than rated voltage. The FCBN designation indicates that a transformer will deliver rated KVA when connected to a voltage source which is lower than rated voltage.

Fan Cooled A means of accelerating heat dissipation to lower the temperature rise of the transformer. This has the effect of increasing the transformer rating.

FL Full-load

Frequency The number of complete cycles per unit for a periodic quantity such as alternating current, sound waves or vibrating objects.

Fuse An overcurrent protective device with a circuit-opening fusible member which is directly heated and severed by the passage of overcurrent through it, or by a fault.

G

Ground A conducting path, whether intentional or accidental, between an electric circuit or equipment and the earth, or some other conductor.

Grounded Connected to the earth or some other conductor.

H

HP Horsepower. Energy required to raise 33,000 pounds one foot in one minute. Equals 746 watts, or .746 KW.

Harmonic A sinusoidal waveform with a frequency that is an integral multiple of the fundamental 60 Hz frequency.

60 Hz	Fundamental
120 Hz	2nd Harmonic
180 Hz	3rd Harmonic
240 Hz	4th Harmonic

etc.

Current waveforms from non-linear loads appear distorted because the non-linear waveform is the result of adding harmonic components to the fundamental current.

Harmonic Distortion Non-linear distortion of a system characterized by the appearance in the output of harmonic currents when the input is sinusoidal.

Harmonic Distortion, Total The square root of the sum of the squares of all harmonic currents present in the load, excluding the 60 Hz fundamental. Usually expressed as a percent of the fundamental.

Hertz (Hz) Cycles per second.

High Voltage Windings In a transformer with two windings, designates the winding with the greater voltage. Usually marked with an "H" designation.

Hysteresis Tendency of a magnetic substance to persist in any state of magnetization.

I

Impedance Total oppostion of a component or circuit to the flow of an alternating or varying current (symbol Z).

Inductance That property of a circuit or circuit element opposing a change in current flow (symbol L). Measured in Henrys.

Input The power or signal fed into an electrical device, or to the terminals involved.

Inrush Current The initial high peak of current during the first few cycles of energization which can be 30 to 40 times the rated current.

Isolating Transformer Transformer in which input winding(s) connected to the line are completely isolated from those connected to the load.

Insulation Material with high electrical resistance.

Insulator Device used for supporting or separating conductors of electricity.

Insulating Transformer Another term for isolation transformer.

K

K-Factor A numerical value taking into account both the magnitude and frequency of the component of a current waveform. Used to indicate a full-rated transformer specifically designed to handle non-linear loads.

Kilowatt (KW) 1,000 Watts.

KWH Kilowatt hour, one kilowatt for one hour.

KVA Kilovolt-ampere, or thousand volt-ampere. When multiplied by the power factor, will give kilowatts, or KW.

L

Linear Loads Loads where the current waveform conforms to that of the applied voltage, or loads where a change in current is directly proportional to a change in applied voltage. For example: resistance heating, incandescent lighting, water heater.

Lamination Thin sheets of steel making up the core of the transformer.

Line Voltage The voltage of the power line.

N

Non-Linear Loads Loads where the current waveform does not conform to that of the applied voltage, or where a change in current is not proportional to change in applied voltage. For example: computer power supplies, motor drives, fluorescent lighting.

Non-Ventilated Construction The core and coil assembly is mounted inside an enclosure which has no ventilation openings.

P

Potted The core and coil assembly is completely encapsulated (contained within protecting material) with a resin-sand compound and contained in a metal enclosure.

Power Factor (PF) A capacitive or inductive circuit condition that results in the applied current leading or lagging the applied voltage.

Peak Voltage The voltage or current of an AC sinusoidal wave when it reaches its peak or maximum level. This occurs twice and lasts for only a fraction of the cycle. Direct current voltage is peak voltage at all times.

S

Short Circuit A low resistance connection, usually accidental, across part of a circuit, resulting in excessive current flow.

Sinusoidal Having the form of a sine (or cosine) wave.

Step-Up/Step-Down Transformers A transformer can either step up or step down voltage. A step-up transformer is one in which the output voltage is greater than the input voltage. With a step-down transformer, the input voltage is greater than the output voltage.

T

Taps Incoming plant voltage varies according to the distance from the substation and other factors. Taps allow a distribution transformer to provide secondary voltage as close as possible to the desired operating voltage. Taps are usually supplied on the primary winding to allow matching of the supply voltage to the voltage rating of the transformer connection. A tap position above the nominal connection will lower the secondary output and vice-versa.

Transformer Regulation The percentage difference between voltage at the secondary terminals under no-load condition versus voltage under full-load. This value depends on the load power factor and is usually reported at 1.0 PF and 0.8 PF.

Turn Ratio The relationship between the number of turns on the transformer's two windings. Voltage is always transformed in exact accordance to this ratio. The amperes, or amount of current, changes in an inverse ratio to the turns ratio. When voltage increases, current decreases in the same proportion, and vice-versa.

U

UL Underwriter's Laboratories. A non-profit safety testing organization.

V

Ventilated Providing circulation of external air.

Ventilated Enclosure Enclosure with openings which allow air to flow directly over the core and coil assembly for cooling.

Volt-Amperes Transformers are rated in volt-amperes (the product of volts and amperes in the input winding). The capacities of very large transformers are rated in thousands of volt-amperes (kilovolt-amperes or KVA) and in millions of volt-amperes (megavolt-amperes or MVA). For all practical purposes, input KVA is equal to output KVA.

W

Watt Unit of electrical power when the current in the circuit is one ampere and the voltage is one volt.

Weathershields When added to ventilated enclosures, allow indoor-rated units to be situated outdoors, changing the enclosure rating to NEMA 3R.