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Solutions Inc.

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transformers



## Energy Efficient Distribution Transformers

*Other HPS Products*



[www.hammondpowersolutions.com](http://www.hammondpowersolutions.com)

# Energy Efficient Transformers



Established in 1917, Hammond Power Solutions Inc. (HPS), is an industry leader in magnetic transformer design and development. With our headquarters in Guelph, Canada, HPS operates out of multiple facilities globally. HPS has expanded its manufacturing and product base to offer the broadest ranges of both standard and specialty transformers.

## LOW VOLTAGE DISTRIBUTION TRANSFORMER ENERGY EFFICIENCY GUIDELINES

In the past several years, there has been an accelerated rate of change to introduce energy efficiency standards for transformers in North America. Many products have preceded these initiatives for transformers in an overall effort to optimize manufactured goods for environmental concerns. Governments are encouraging users to consider energy efficient products like dry-type transformers, to help reduce carbon dioxide emissions.

In addition to the benefits to the environment, energy efficient transformers realize substantial savings in operating costs, thereby having a direct impact on the initial investment evaluated over a period of time.





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## CONSTRUCTION FEATURES

*HPS transformers are designed and constructed to meet or exceed the requirements for general applications. Construction features of HPS Energy Efficient Distribution Transformers include:*

### **Core Construction**

HPS cores are manufactured from the highest quality non-aging, cold rolled, silicon steel laminations. Cores are precision cut to close tolerances to eliminate burrs and interleaved to improve performance. Full mitre stepped core construction is used for our very high efficiency transformers.

### **Coil Construction**

Coils are available in either aluminum or copper construction. Coils are precision wound with continuous copper or aluminum conductors and are electrically balanced to minimize axial short-circuit forces. The use of duct stick permits the flow of air, thus providing excellent cooling in addition to providing superior radial mechanical strength.

### **Insulation System**

The insulation rating is the maximum allowable winding (hot spot) temperature of a transformer operating at an ambient temperature of 40°C. Insulation systems are classified by the temperature rating. HPS energy efficient distribution transformers utilize superior insulation materials which meet or exceed UL standards. Higher ambient temperatures and/or continuous overload characteristics can be achieved with low temperature rise design.

### **Terminations**

HPS transformers are provided (where applicable) with both high and low voltage terminal lug connectors suitable for both copper and aluminum cables. These connectors allow for easy field installation without the need to purchase connectors separately, saving the installer both time and money.

### **Vacuum Pressure Impregnation (VPI)**

Regardless of voltage class, our polyester resin impregnation system is preferred. This material is a blend of a vinyl-toluene polyester resin and exhibits much higher dielectric strength and bonding properties than most varnishes previously used, or other encapsulations including oil modified epoxies. The VPI process ensures that the insulating resin penetrates all voids completely, and provides a superior result compared to simple dip and bake operations.

### **Testing**

HPS has testing facilities in all manufacturing locations to ensure product quality. These testing capabilities include: Heat Run, Ratio, Polarity, Partial Discharge, Induced Voltage Test, Sound Level, Transformer Losses under linear and non-linear load conditions, Applied Power Frequency Voltage Test, EMF, BIL, Insulation Resistance, Inductance and Resistance. HPS has a state-of-the-art test bench that can test transformer efficiencies with non-linear load profile up to K-Factor 20.



Core Construction



Coil Construction



Terminations



VPI



Testing

# Energy Efficient Transformers



## CANADA - ENERGY EFFICIENCY (CSA C802.2)

The laws in Canada state that all low voltage dry-type distribution transformers (see table) manufactured after January 1st, 2005, must meet the minimum energy efficiency guidelines outlined by CSA C802.2 and referenced in the Canadian Energy Efficiency Act - Energy Efficiency Regulations (SOR/94-651). "Maximum Losses for Distribution, Power and Dry-Type Transformers". The HPS lines of 1.2kV class energy efficient distribution transformers illustrated in this section, meet or exceed the minimum efficiencies required. These efficiencies are evaluated at 35% of the nameplate kVA transformer capacity. The range of product covered by these standards are:

<b>Primary (high) Voltage</b>		<b>1.2kV</b>
<b>Secondary (low) Voltage Line Current</b>		<b>Less than 4000 amps</b>
<b>Dry-Type Rating</b>	<b>Single Phase</b>	<b>15-333kVA</b>
	<b>Three Phase</b>	<b>15-1000kVA</b>
<b>Frequency</b>		<b>60 Hz only</b>

## UNITED STATES - ENERGY EFFICIENCY (DOE 10 CFR PART 431/TP1)

The laws in the U.S. state that all low voltage dry-type distribution transformers (see table) manufactured after January 1st, 2007, must meet the minimum energy efficiency standards outlined in DOE 10 CFR Part 431 (typically referred to as TP1). "Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule". The HPS lines of 600 volt class energy efficient distribution transformers illustrated in this section meet or exceed the minimum efficiencies required. These efficiencies are evaluated at 35% of the nameplate rated load. The range of product covered by these standards are:

<b>Voltage Rating</b>	<b>Primary Voltage</b>	<b>600 volt and below</b>
	<b>Secondary Voltage</b>	<b>600 volt and below</b>
<b>Dry-Type Rating</b>	<b>Single Phase</b>	<b>15-333kVA</b>
	<b>Three Phase</b>	<b>15-1000kVA</b>
<b>Frequency</b>		<b>60 Hz only</b>



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## NEMA PREMIUM® EFFICIENCY TRANSFORMER PROGRAM

On June 9<sup>th</sup>, 2010 the National Electrical Manufacturers Association (NEMA) announced the initiation of the NEMA Premium® Efficiency Transformer Program, which will help utilities, commercial buildings, and industrial plants incorporate super high-efficiency transformers into their operations. The adoption of this program will not only reduce energy consumption, but will also reduce carbon dioxide emissions.



The new NEMA Premium® Efficiency Transformer designation requires 30 percent fewer losses than existing DOE regulations (10 CFR 431)/TP1 for low-voltage dry-type distribution transformers. Below is a comparison between the NEMA Premium efficiency levels versus the DOE 10 CFR Part 431/TP1 and C802.2 efficiency levels.

### Single Phase - Low Voltage

kVA Rating	DOE/TP1 & C802.2	NEMA Premium®
15	97.70%	98.39%
25	98.00%	98.60%
37.5	98.20%	98.74%
50	98.30%	98.81%
75	98.50%	98.95%
100	98.60%	99.02%
167	98.70%	99.09%
250	98.80%	99.16%
333	98.90%	99.23%

### Three Phase - Low Voltage

kVA Rating	DOE/TP1 & C802.2	NEMA Premium®
15	97.00%	97.90%
30	97.50%	98.25%
45	97.70%	98.39%
75	98.00%	98.60%
112.5	98.20%	98.74%
150	98.30%	98.81%
225	98.50%	98.95%
300	98.60%	99.02%
500	98.70%	99.09%
750	98.80%	99.16%
1000	98.90%	99.23%

For more information about the NEMA Premium® Efficiency Transformer Program, visit:  
<http://www.nema.org/Technical/Pages/NEMA-Premium-Efficiency-Transformers-Program.aspx>

**As a Partner in the NEMA Premium® Efficiency Transformer Program, HPS has determined that the HPS SuperSentinel, HPS SuperSynergy, and HPS SuperCenturion meet the NEMA Premium® Efficiency guidelines for super high-efficiency.** (NEMA Premium® is a trademark of National Electrical Manufacturers Association.)

# Energy Efficient Transformers



## DISTRIBUTION TRANSFORMER PRODUCTS & APPLICATIONS

HPS offers three types of low voltage energy efficient distribution transformers, they include:

### **Linear Load General Purpose Transformers - HPS Sentinel® & HPS SuperSentinel®**

They are generally used for supplying appliance, lighting, heating, motorized machine and power loads from electrical distribution systems. They are either ventilated, totally enclosed. For non-linear loads, all standard energy efficient general purpose distribution transformers have to be derated to allow for additional heat due to harmonic losses (see HPS Synergy below).



#### **HPS SENTINEL (PART NUMBER PREFIX NMK OR NMF)**

- Meets **DOE 10 CFR Part 431/TP1** and **C802.2** efficiencies at **35%** of rated load.
- Efficiencies are calculated under a **linear load profile**.

#### **HPS SUPERSENTINEL (PART NUMBER PREFIX SMK OR SMF)**

- **Exceeds DOE 10 CFR Part 431/TP1** and (if applicable) **CSA C802.2** efficiencies at **35%** of rated load.
- Efficiency performance will meet the **NEMA Premium®** guidelines; **30% lower losses** than DOE 10 CFR Part 431/TP1 and (if applicable) CSA C802.2 standards; when measured under a linear load profile.



### **Non-Linear Load K-Factor Transformers - HPS Synergy® & HPS SuperSynergy®**

Energy efficient K-factor transformers are designed to tolerate heating due to harmonics associated with non-linear loads. They have become a popular means of addressing these related overheating problems where electronic ballasts, drives, personal computers, telecommunications equipment, broadcasting equipment and other similar power electronics are found in high concentrations. Harmonics can indicate their presence in a number of ways: overheating, device malfunctions, telephone interference, equipment vibration, and breakers tripping. These non-linear loads generate harmonic currents which can substantially increase transformer losses. The K-rated transformer has a more rugged design intended to prevent failure due to overheating, a 200% rated neutral and full electrostatic shield.



K-factor is defined as a ratio between the additional losses due to harmonics and the eddy current losses at 60Hz. It is used to specify transformers for non-linear loads. Standard K-factor ratings are 4, 13, 20 and other ratings are available.

#### **HPS SYNERGY (PART NUMBER PREFIX NMT)**

- Meets **DOE 10 CFR Part 431/TP1** and **C802.2** efficiencies at **35%** of rated load.
- Efficiencies are calculated under a **linear load profile**.

#### **HPS SUPERSYNERGY (PART NUMBER PREFIX SMT)**

- Efficiency performance will meet the **NEMA Premium®** guidelines; **30% lower losses** than DOE 10 CFR Part 431/TP1 and (if applicable) CSA C802.2 efficiency standards; when measured under a linear load profile at **35%** of rated load.
- Efficiency will meet or exceed DOE 10 CFR Part 431/TP1 and (if applicable) CSA C802.2 efficiency standards for linear load even at **50%** of rated load when measured under a **non-linear** load up to **K13**.





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### **Harmonic Mitigating Transformers - HPS Centurion® & HPS SuperCenturion®**

Harmonic Mitigating transformers are superior to K-rated and general purpose transformers in that they reduce voltage distortion (flat-topping) and power losses due to current harmonics created by single-phase, non-linear loads such as computer equipment. Secondary windings are arranged to **cancel** zero sequence fluxes and eliminate primary winding circulating currents. They treat zero sequence harmonics (3rd, 9th and 15th) within the secondary windings and 5th and 7th harmonics upstream with appropriate phase shifting.



Dual output, phase shifting Harmonic Mitigating Transformers provide extremely low output voltage distortion and input current distortion even under severe non-linear load conditions (Data Centers, Internet Service Providers, Telecom Sites, Call Centers, Broadcasting Studios, etc.). Combining zero sequence flux cancellation with phase shifting treats 3rd, 5th, 7th, 9th, 15th, 17th and 19th harmonics within its secondary windings.

#### **Features of Harmonic Mitigating Transformers:**

- Prevents voltage flat-topping caused by non-linear loads
- Reduces upstream harmonic currents
- Eliminates transformer overheating and high operating temperatures
- Eliminates primary winding circulating current
- Saves energy by reducing harmonic losses
- Maintains high energy efficiency even under severe non-linear loading conditions
- Electrostatic shielding for high frequency noise attenuation
- Reduces voltage distortion to prevent premature equipment failure
- Increases ride-through capability of computer equipment
- Treats power quality harmonic issues which K-rated transformers do not address
- Suitable for high K-factor loads
- Reduces current distortion at UPS, generator or Utility service
- Improves Upstream Total Power Factor
- Helps meet IEEE Standard 519 harmonic limits

#### **HPS CENTURION (PART NUMBER PREFIX H1EM OR H2EM)**

- Meets **DOE 10 CFR Part 431/TP1** and **C802.2** efficiencies at an operating range from **35% to 65%** of rated linear load.
- Meets **DOE 10 CFR Part 431/TP1** and **C802.2** efficiency standards when measured under a **non-linear** load profile up to **K20** in an operating range from **35% to 50%**.

#### **HPS SUPERCENTURION (PART NUMBER PREFIX S1EM OR S2EM)**

- **Exceeds DOE 10 CFR Part 431/TP1** and (if applicable) **C802.2** efficiencies at **35%** of rated load.
- Efficiency performance will meet **NEMA Premium®** guidelines; **30% lower losses** than **DOE 10 CFR Part 431/TP1** and (if applicable) CSA C802.2 efficiency standards when measured under a linear load profile.
- Efficiencies will exceed **DOE 10 CFR Part 431/TP1** and (if applicable) CSA C802.2 standards at an operating range from **35% to 65%** of rated load when measured under a **non-linear** load profile up to **K20**.



\* For a complete listing of HPS Energy Efficient part numbers, please refer to the HPS online catalog.

# Energy Efficient Transformers



The following chart illustrates the standard features of HPS Energy Efficient Low Voltage Distribution transformers for General Purpose, K-Factor and Harmonic Mitigating Transformers.

## Distribution Transformer Standard Features Chart

Standard Features/Options Description	SENTINEL® Series (General Purpose - for linear loads)	SYNERGY® Series (K-Factor - for non-linear loads)	CENTURION® Series (Harmonic Mitigating - for linear & non-linear loads)
<b>STANDARD FEATURES</b>			
<b>kVA Range</b>			
Single Phase: 15kVA - 333kVA	✓		
Three Phase: 15kVA - 1000kVA	✓	✓	✓
<b>Frequency</b>			
60 Hertz	✓	✓	✓
<b>Winding Material</b>			
Aluminum	✓	✓	✓
Copper	✓	✓	✓
<b>Shielding</b>			
Single Shield	OPT	✓	✓
Double Shield	OPT	OPT	OPT
<b>Primary Taps</b>			
Meet or Exceed NEMA	✓	✓	✓
Custom Primary Taps	OPT	OPT	OPT
<b>Enclosure Rating</b>			
Type 3R	✓	✓	✓
Type 3RE, Type 4, Type 4X (HPS standard is stainless steel), Type 12	OPT	OPT	OPT
<b>Enclosure Finish</b>			
ANSI 61 Grey, UL50	✓	✓	✓
Custom Sprayed-On Water Based Paint	OPT	OPT	OPT
Custom Baked-On Enamel Paint	OPT	OPT	OPT
Stainless Steel (304 or 316)	OPT	OPT	OPT
<b>Insulation System</b>			
15 to 30kVA Cu      130°C Temperature Rise, 200° Insulation Class	✓	✓	✓
15 to 30kVA Cu      115°C Temperature Rise, 200° Insulation Class	OPT	OPT	OPT
15 to 30kVA Cu      80°C Temperature Rise, 200° or 220° Insulation Class	OPT	OPT	OPT
15 to 30kVA Al      150°C Temperature Rise, 220° Insulation Class	✓	✓	
15 to 30kVA Al      80°C, 115°C, 130°C Temperature Rise, 220° Insulation Class	OPT	OPT	✓
45 to 750kVA Cu & Al      150°C Temperature Rise, 220° Insulation Class	✓	✓	
45 to 750kVA Cu & Al      130°C Temperature Rise, 220° Insulation Class	OPT	OPT	✓
45 to 750kVA Cu & Al      80°C, 115°C Temperature Rise, 220° Insulation Class	OPT	OPT	OPT



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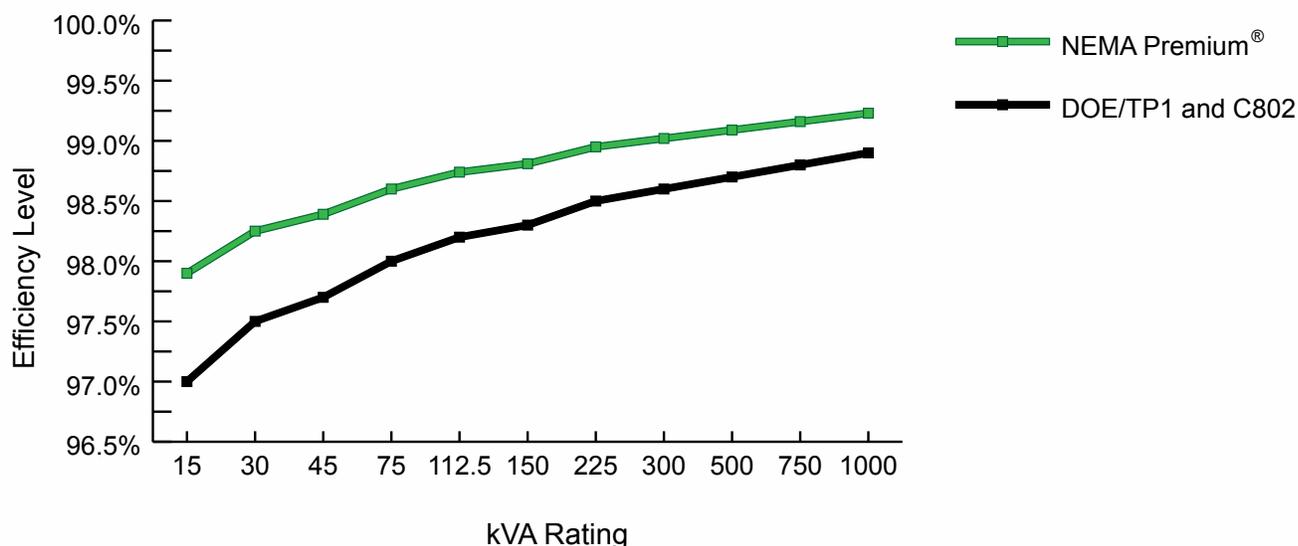
Standard Features/Options Description	SENTINEL® Series (General Purpose - for linear loads)	SYNERGY® Series (K-Factor - for non-linear loads)	CENTURION® Series (Harmonic Mitigating - for linear & non-linear loads)
<b>Impedance</b>			
Typically 2.5% to 6.5%	✓	✓	✓
Custom Impedance	OPT	OPT	OPT
<b>Sound Level</b>			
Meets NEMA ST-20	✓	✓	✓
Options below NEMA ST-20 available	OPT	OPT	OPT
<b>K-Factor Nameplate Rating</b>			
K-Factor 4 (Load Profile up to K9)		✓	
K-Factor 13 (Load Profile up to K20)		✓	✓
K-Factor 20 (Load Profile up to K30)		✓	OPT
Other		OPT	OPT
<b>Neutral</b>			
100% of Nameplate under linear loads	✓		
200% Neutral		✓	✓
<b>Internal Phase Shifting</b>			
0°			✓
30°	✓	✓	✓
0° & 30° or 15° & 45°			OPT
Other			OPT
<b>Secondary Output</b>			
Single	✓	✓	✓
Dual			OPT
<b>Duty</b>			
Standard Duty	✓	✓	✓
Drilling Duty	OPT	OPT	OPT
Marine Duty	OPT	OPT	OPT
<b>Accessories</b>			
Many accessories available, please consult factory for details	✓	✓	✓

# Energy Efficient Transformers



## NEMA PREMIUM® SAVINGS VERSUS STANDARD EFFICIENCY TRANSFORMERS

The graph below illustrates the difference between the standard energy efficiency levels (DOE/TP1 and C802.2) and the NEMA Premium® efficiency levels for three phase kVA ratings:



HPS has an Energy Savings Calculator available on the HPS Tool Box website ([www.hpstoolbox.com](http://www.hpstoolbox.com)) designed to help calculate energy cost savings using HPS Energy Efficient Distribution Transformers. The table below demonstrates the savings for a typical Industrial plant with a 75kVA transformer (operating 300 days/year and loading at 100% 16hrs/day and 50% 8hrs/day) using the HPS Energy Savings Calculator.

Transformer	Annual		
	Energy Consumption (kWh)	Energy Costs	Energy Savings
<b>DOE (TP1)/C802.2 Compliant Transformer</b>			
HPS Sentinel Energy Efficient General Purpose	12808.5	\$1,280.85	\$885.57 (vs. Non-DOE/C802.2)
<b>NEMA Premium® Transformers</b>			
HPS SuperSentinel Super Energy Efficient General Purpose	9017.3	\$901.73	\$1,264.69 (vs. Non-DOE/C802.2) \$344.33 (vs. DOE/C802.2)

Visit the HPS Tool Box ([www.hpstoolbox.com](http://www.hpstoolbox.com)) Energy Savings Calculator to find out how HPS can help reduce your energy consumption, and costs for your application.



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## HPS STANDARD FEATURES PLUS BENEFITS EQUALS COST SAVINGS

These standard options save contractors time and labor:

Features	Benefits	Contractor Savings	
		Cost (\$)	Time (min.)
Primary Terminal Lugs*	Primary Terminal Lugs included with most kVA ranges. Purchase of separate lugs to install at additional cost not required.	\$25 to \$100	30 min.
Secondary Terminal Lugs*	Secondary Terminal Lugs included with most kVA ranges. Purchase of separate lugs to install at additional cost not required.	\$25 to \$100	30 min.
Standard Conduit Knock Outs*	Save installation time by eliminating the need to punch conduit entry holes.	\$45 to \$75	20 min.
Drip Shield	Additional protection for the transformer from falling water. Drip shield included. Purchase and installation of Drip Shield not required.	\$50 to \$200	15 to 30 min.
Wall Mounting Brackets*	Helps to save space. Wall mounting brackets included on units up to 45kVA.	\$50 to \$150	15 to 30 min.
Base Mounting Holes Pointed Outward*	Easy access for mounting.	\$10 to \$50	5 to 15 min.
Horizontal Vent Screens	Added cooling effect.		
Laminated High Efficiency Steel Core	Optimum energy efficiency. Improved performance.		
Coils - VPI Polyester Resin	Exhibits much higher dielectric strength and bonding properties than any varnishes previously used, or other encapsulations including oil modified epoxies. Longevity of life at maximum transformer temperatures.		
Heavy-Duty Mounting Feet or Base Channel	Provides superior support in all mounting conditions and decreases possibility of shipping damage.		Reduces returns due to freight damage.
Standard NEMA 3R Rated Enclosure	May be used for either indoor or outdoor use (also available in a non-ventilated version). No assembly required.		No special order or additional parts required.
Loop Taps	Does not require additional brazing during construction and eliminates brazed joints.		
Aluminum or Copper Windings	More options based on budget.		

\* see HPS catalog for range

**~ Estimated Total Savings ~**

**Time: 1 hrs 55 min to 2 hrs 35 min**

**Material & Labor Cost: \$205 to \$675**

# Energy Efficient Transformers



## CANADA

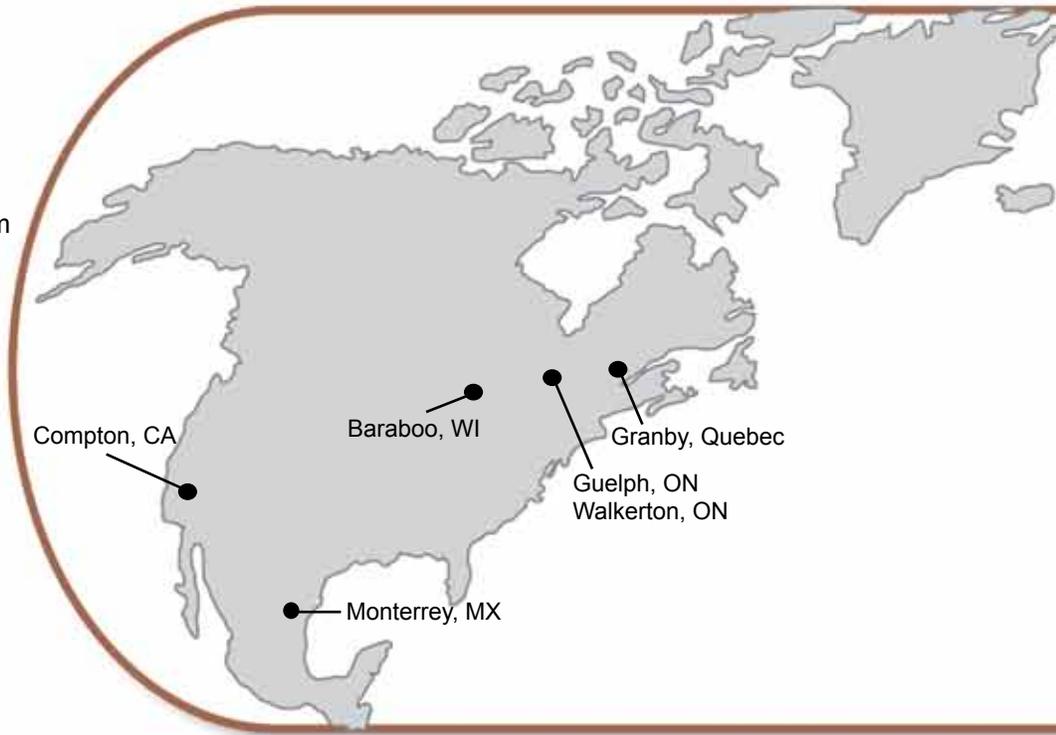
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