MARCH 2019

# Hi-Tech® current-limiting fuses

Safety, reliability and service.

# Hi-Tech current-limiting fuses

Why Hi-Tech?

Introduction to current-limiting fuses

Expulsion vs. current-limiting fuses

Current-limiting fuses

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# Hi-Tech current-limiting fuses

Why Hi-Tech?

# Why Hi-Tech?

## Safety, reliability and service

**Safety**

- Provides maximum system protection that other protective devices may not fully cover
- Space-saving form factors reduce equipment costs and provide easy installation even in retrofit applications

**Reliability**

- Complete line of current-limiting fuses with some of the lowest energy let-through values in the industry for maximum protection

**Service**

- Dedicated application support as well as online configurator for immediate information when it’s needed
- Assembled in Hickory, North Carolina

# Hi-Tech current-limiting fuses

Introduction

# Introduction to current-limiting fuses

Protects equipment, environment and people

**Expulsion fuse example**

**Disclaimer:** The above YouTube video depicts an actual transformer failure. It is not an ABB video and does not involve our product. It is shown here for demonstrative purposes to illustrate a failure in an unprotected system.

A current-limiting backup fuse could have limited this catastrophic failure to a simple fuse operation.

- Preventing violent expulsion of parts
- Protecting people and equipment from harm and damage

# Hi-Tech current-limiting fuses

Expulsion vs. current-limiting fuses

# Expulsion vs. current-limiting fuses

Product comparison

## Expulsion fuse

**Traditional-type fuse**

- Interrupts the flow of current at the natural current zero
- Does not modify the circuit
- Does not reduce the energy levels during a fault

## Current-limiting fuse

**Engineered to maximize protection**

- Interrupts high fault currents in one-half cycle or less
- Creates an arc-voltage to modify the circuit and force current to zero
- Drastically decreases the energy and duration of a short circuit fault to the highest levels of safety and minimizes damages

# Expulsion vs. current-limiting fuses

## Under-oil expulsion fuses

**Expulsion fuses are the basic level of protection:**

- Common on single- and three-phase distribution transformers
- Does not modify the circuit
- Interruption occurs at the natural current zero
- Does not reduce energy levels during a fault

**Not designed for faults internal to the transformer:**

- Limited interrupting capabilities: 3500 amps or less
- Capabilities vary based on application voltage
- Not designed to interrupt high X/R or TRV conditions
- Require additional isolation link if not paired with current-limiting fuse

Expulsion fuses are often used in series with an under-oil partial-range current-limiting fuse to maximize the level of protection and safety.

# Expulsion vs. current-limiting fuses

## Overhead expulsion fuses: cutouts

**Same concept as under-oil expulsion fuses:**

– Protect overhead transformers and capacitor banks by fusing outside the transformer

**Cutouts offer higher interrupting capabilities:**

– Interruption still occurs at the natural current zero

– Large outgassing/expulsion action into the surrounding environment

– Lets through high energy levels during operation

– Loud

Can be used in series with a partial-range current-limiting fuse to offer superior protection to equipment, environment and people.

# Hi-Tech current-limiting fuses

Current-limiting fuses

# Current-limiting fuses

## Types

**Today there are two primary types of current-limiting fuses:**

- Backup fuses
- Full-range fuses/capacitor fuses

**General-purpose fuses (outdated)**

- Only rated to clear currents that cause melting in 1 hour or less

**Designs are engineered to maximize protection:**

- Increases maximum interrupting capability
- Creates an arc-voltage to modify the circuit and force current to zero
- Interrupts high faults currents in one-half cycle or less
- Drastically decreases the energy and duration of a short circuit fault to maximize safety and minimize equipment damage
- Minimizes outage area and collateral damage that must be repaired

# Current-limiting fuses

## Full-range backup fuses

**Backup fuses must be used in series with an expulsion fuse:**

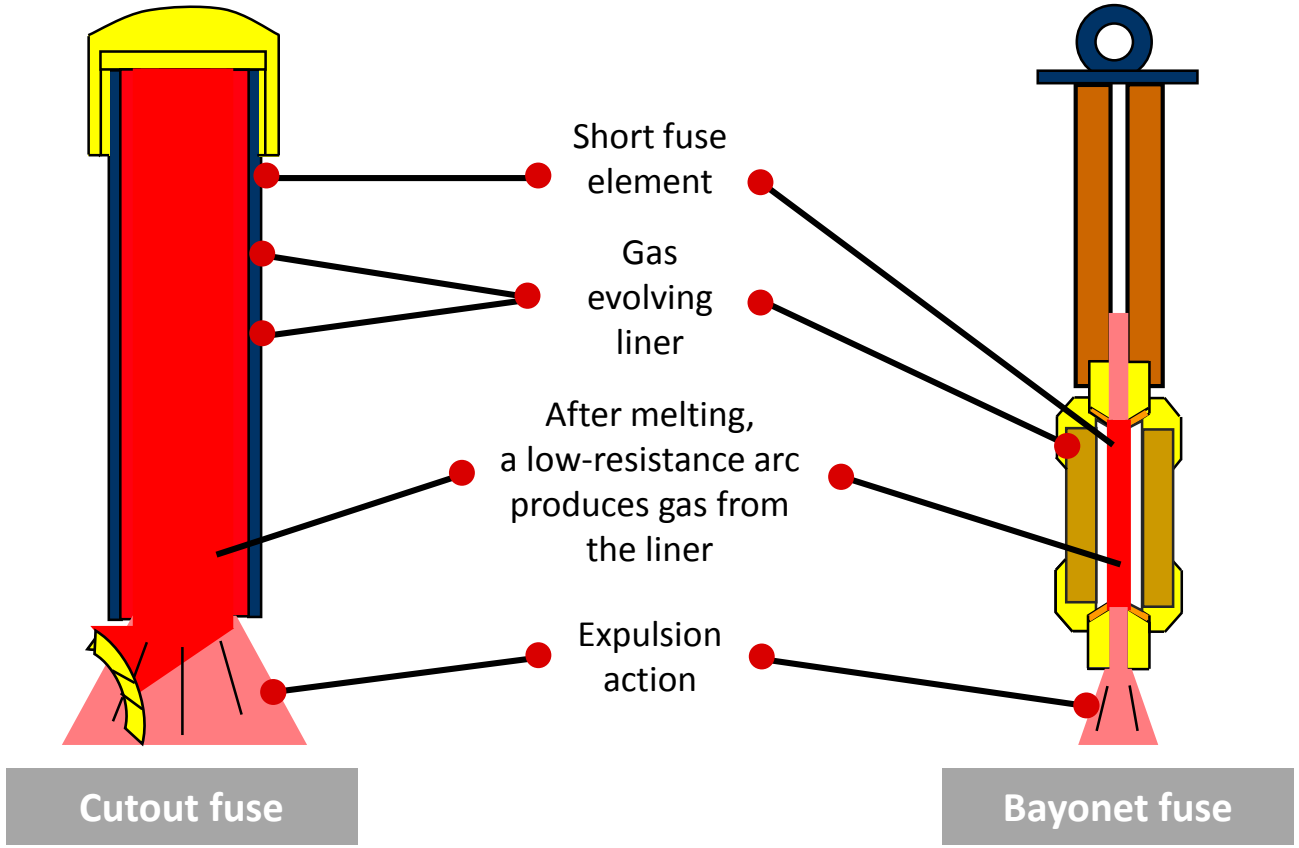
- Copper fuse element with precision notches for high fault currents
- The expulsion fuse protects the backup fuse from currents it cannot interrupt
- The two-fuse approach minimizes the risk of eventful equipment failure
- Selected based on time current curve coordination or match-melt coordination

**Full-range fuses are two fuses in one body:**

- Contains two types of fuse elements: high and low current
- Self-protecting and capable of clearing any current that causes the fuse element to melt
- No outgassing, flames or molten material released into environment
- Selected based on continuous current requirement and overloading demands
- Offered in many different hardware/mounting configurations

# Current-limiting fuses

## Expulsion fuse operation

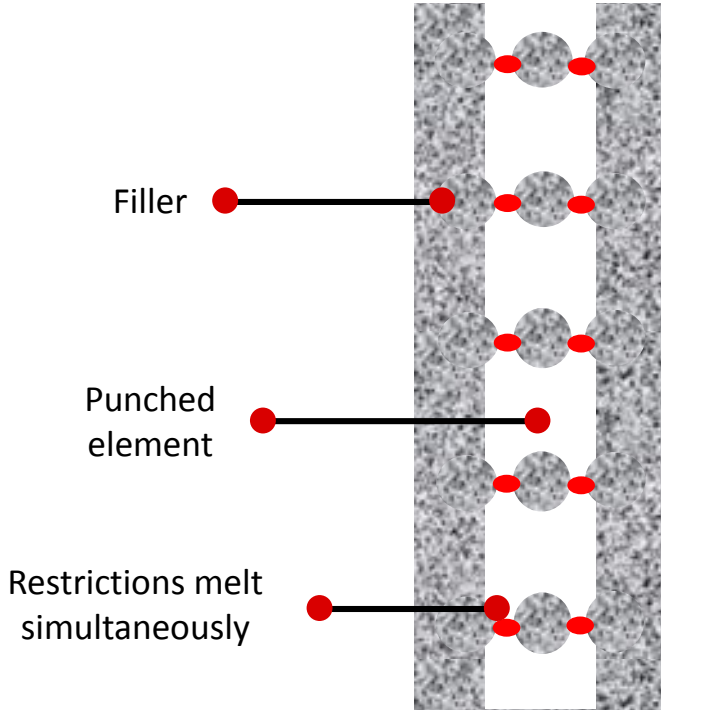


# Current-limiting fuses

## Expulsion vs. current-limiting

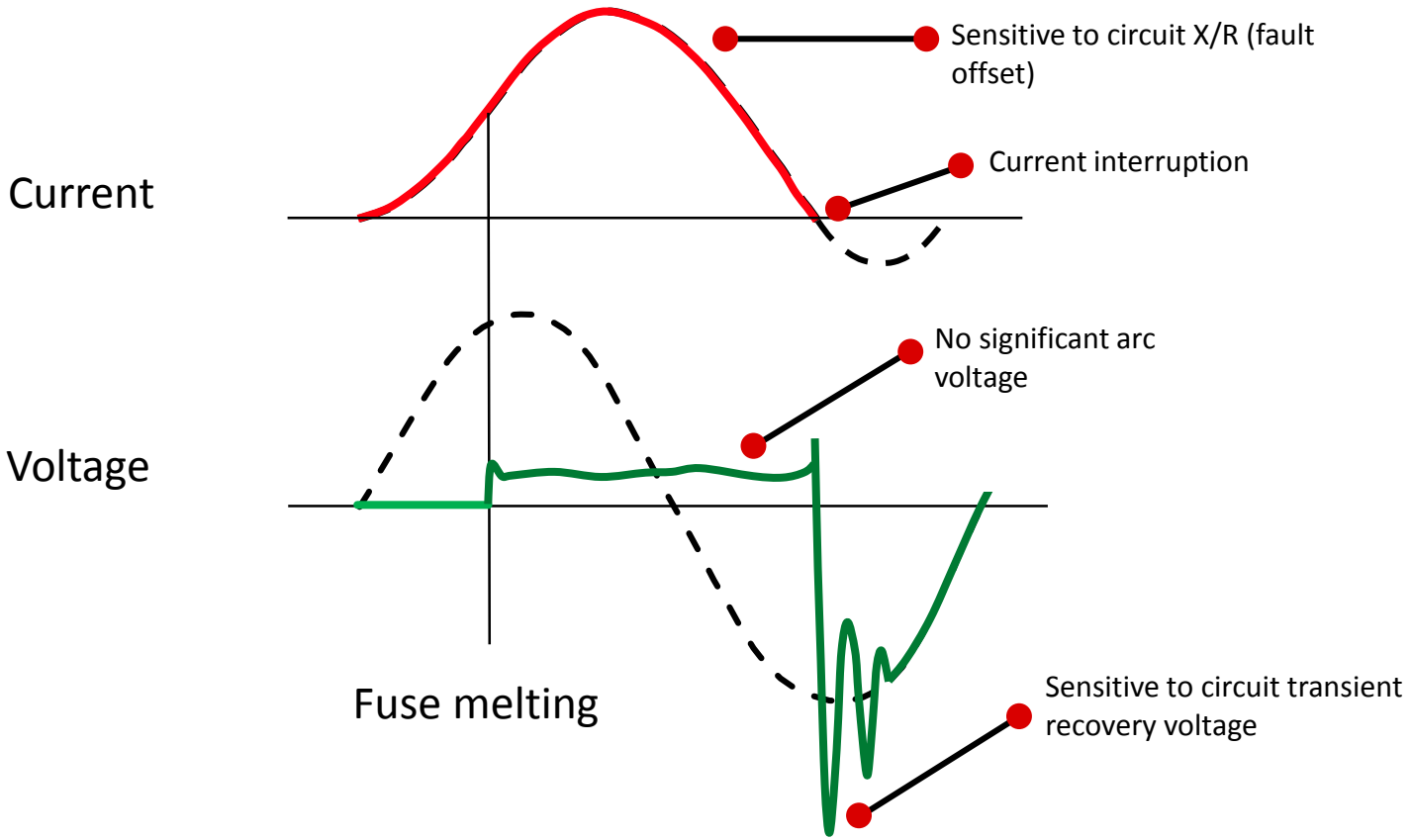
**Construction — Current-limiting backup fuse**

- A current-limiting fuse uses a long element with many series restrictions
- At high currents, the restrictions melt simultaneously, producing a high arc resistance
- This resistance produces an arc voltage across the fuse that works against the system voltage
- This modifies the circuit and drives the current to zero before the natural current zero



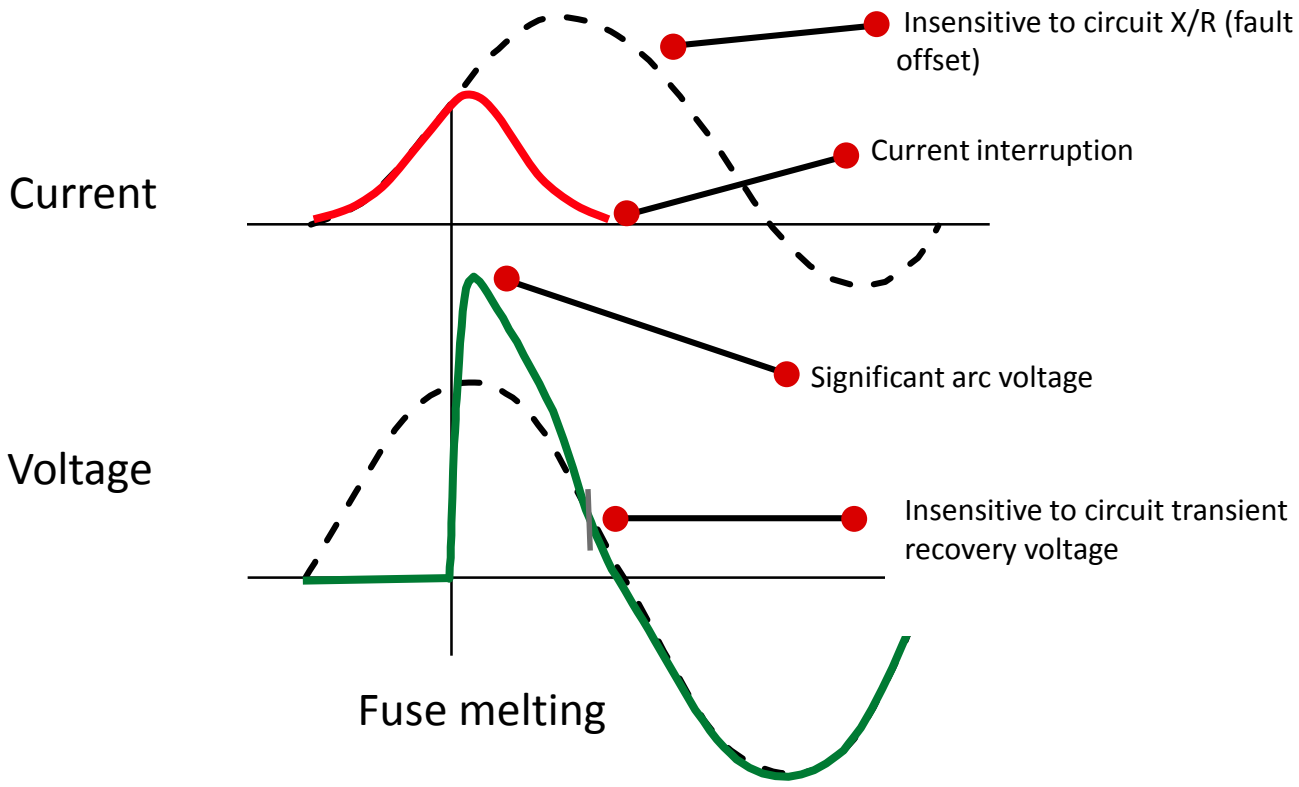
# Current-limiting fuses

Expulsion vs. current-limiting — expulsion fuse



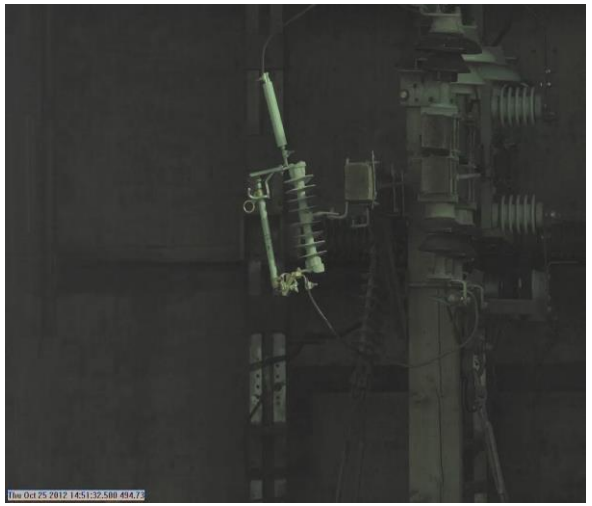
# Current-limiting fuses

Expulsion vs. current-limiting — current-limiting backup fuse



# Current-limiting fuses

Application — protects equipment, environment and people



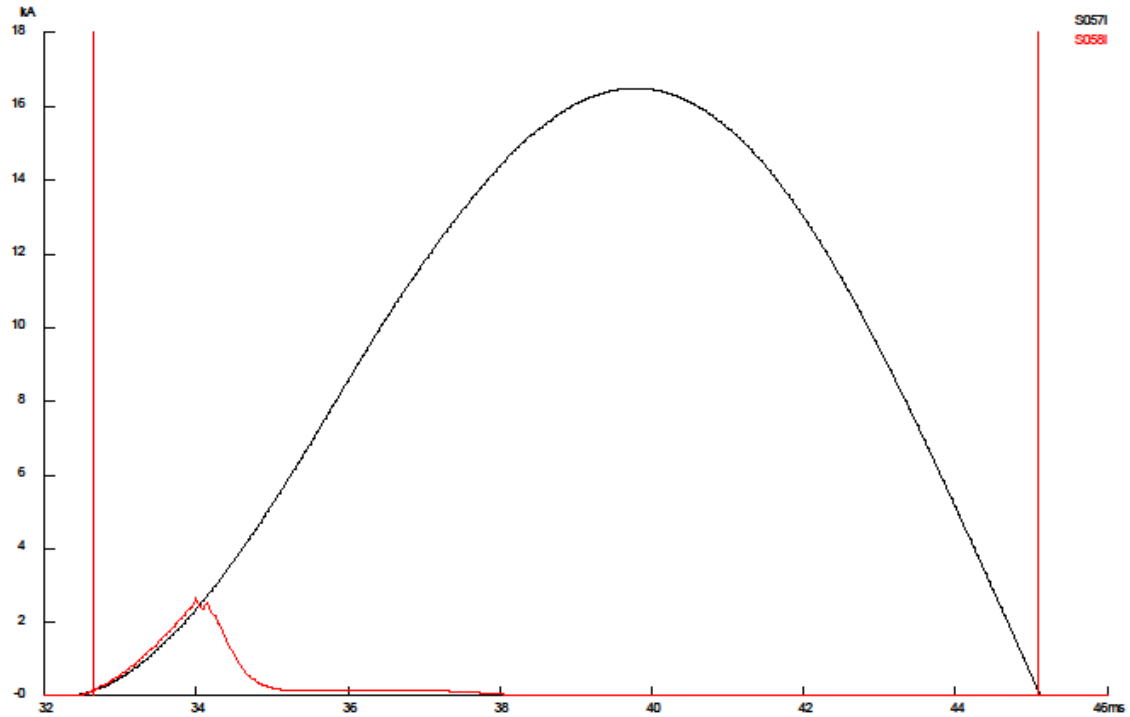
**Current-limiting fuse operation**

**Note:** This video shows an ABB Hi-Tech current-limiting fuse under testing. 12 kA available peak current limited to 2.8 kA in test.

- Prevents violent expulsion of parts
- Interrupts the fault, preventing equipment damage
- Better protection of personnel
- MAXIMUM safety and MINIMUM risk

# Current-limiting fuses

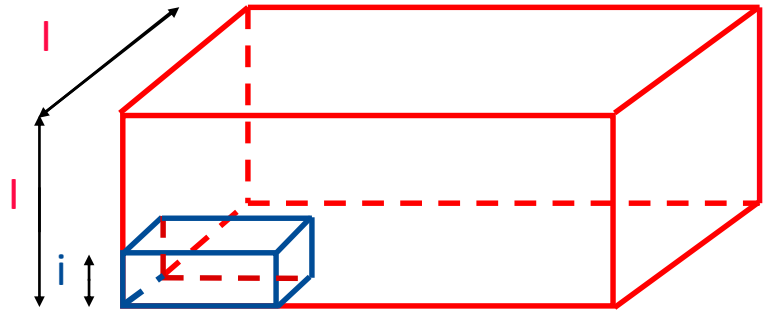
Expulsion vs. current-limiting

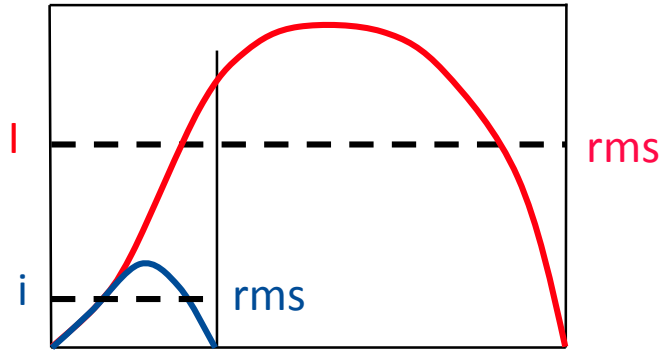



**Peak current limited to 17% by use of a current-limiting fuse: Increased safety due to drastic reduction in $I^2t$ let-through.**

# Current-limiting fuses

Energy reduction




**Fault current 5000 A RMS symmetrical**

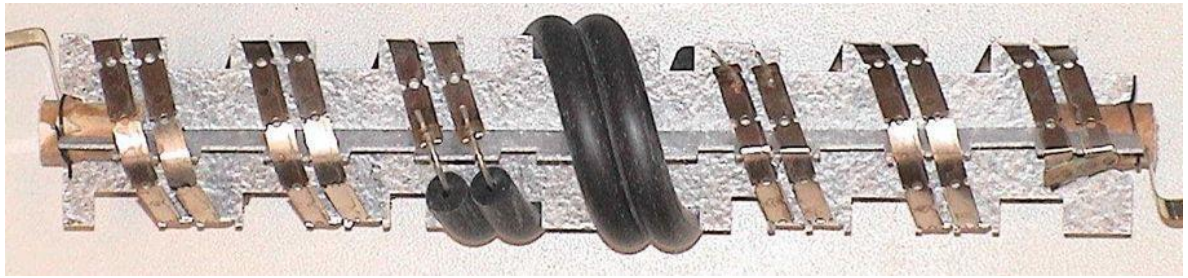
**Expulsion fuse**
**First loop 875,000 $A^2$-sec.**
**Peak current 12 kA**

$I^2t$ let-through by Hi-Tech 12K EXT = 10,000 $A^2$-sec (1.14%)
Peak current limited to: 3.2 kA (26%)

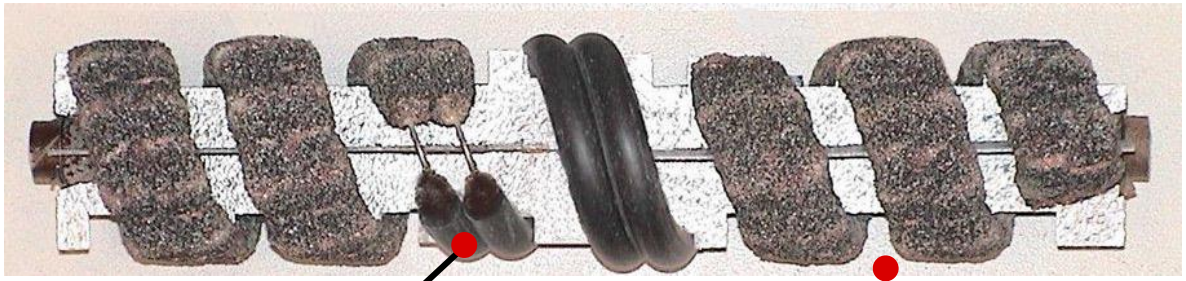
Current-limiting fuses are the only products that work against an internal fault condition to reduce energy and clear the fault well before a natural current zero crossing.

# Current-limiting fuses

Before and after — 8.3 kV full-range fuse after a 5000 amp fault current



Element assembly (new)

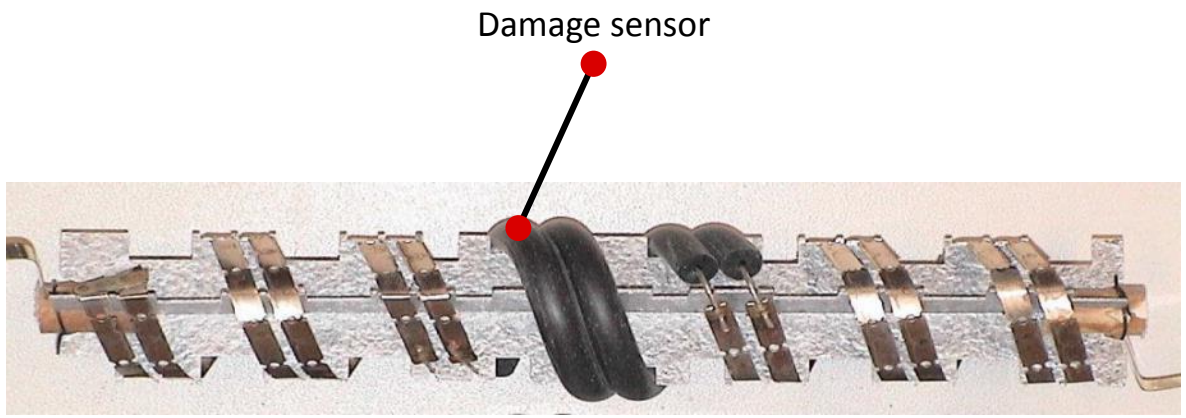



Element assembly after operation

# Current-limiting fuses

## Hi-Tech exclusive patented damage sensor

- Hi-Tech patented damage sensor provides safe fuse operation from damaging surges, which might otherwise result in catastrophic failure
- Ensures fuse integrity and system reliability



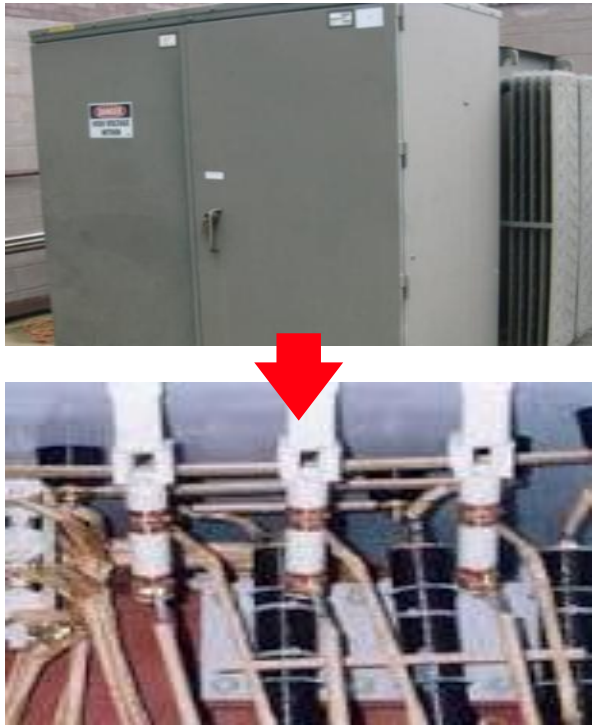
# Hi-Tech current-limiting fuses

Applications

# Applications

## OEM: Padmount distribution transformers — OS shorty (HTSS)

- Provides distribution transformer protection and only operates during an internal transformer fault, limiting costly equipment damage that expulsion fuses cannot interrupt
- Durable design, compact size, low current let-through and 100% factory testing maximizes protection and improves personal and equipment safety
- Update utility specifications to specify Hi-Tech fuses for maximum protection and versatility in original equipment, while improving overall system reliability



**Oil-submersible in three-phase transformer**

# Applications

## Overhead transformer protection — external backup fuses

Provides protection against damage to surrounding infrastructure and personnel by significantly reducing energy let-through during internal transformer failure, thus preventing catastrophic failure.

Backup fuse with pole-mounted transformer

Zoomed: Backup fuse and cutout

# Applications

## Reduction in voltage dips

- When a fault occurs on a power system, all customers in an affected area will experience a drop in voltage for the duration of the fault
- Faults occurring on the primary side of step-down transformers produce the largest effect
- A current-limiting fuse reduces the duration of a voltage dip on the system to its melting time, with the fraction of a millisecond it takes for the fuse arc voltage to equal the system voltage

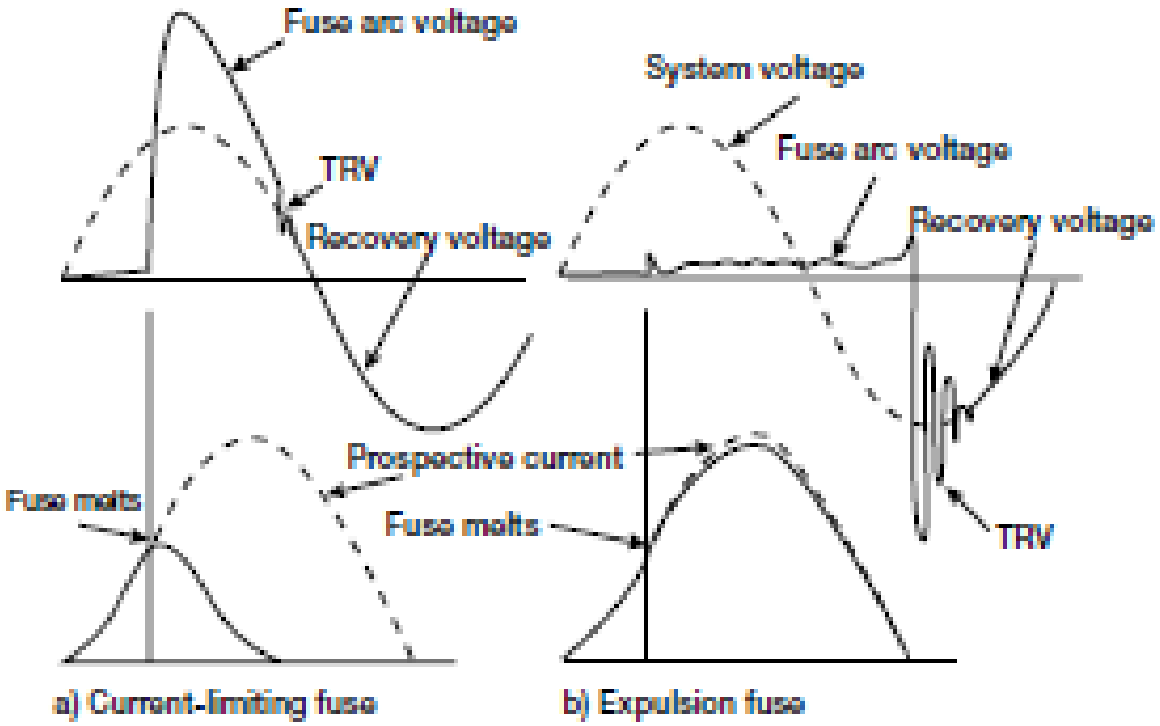



Figure 1

# Applications

## Fire/hazard safety

- When regulation or standards call for non-expulsion system protection
- In areas where fire or personnel could be at risk
- In areas of close personal property
- In industrial areas
  - Also helps protect customer equipment

# Applications

## Capacitor bank protection — external backup fuses or full-range fuses

Protects against internal capacitor failures and/or high over-current bank fault conditions, helping to avoid catastrophic failure of the equipment and associated damage.

**Two-fuse approach for protecting overhead capacitor bank**

**Full-range capacitor fuses**

# Applications

Industrial switchgear protection — HTFX and HTSX products

Full-range protection from overloads to short circuit fault currents, mitigating damage to equipment and exposure to personnel.

Trans-Guard FX full-range fuse for dry canister application

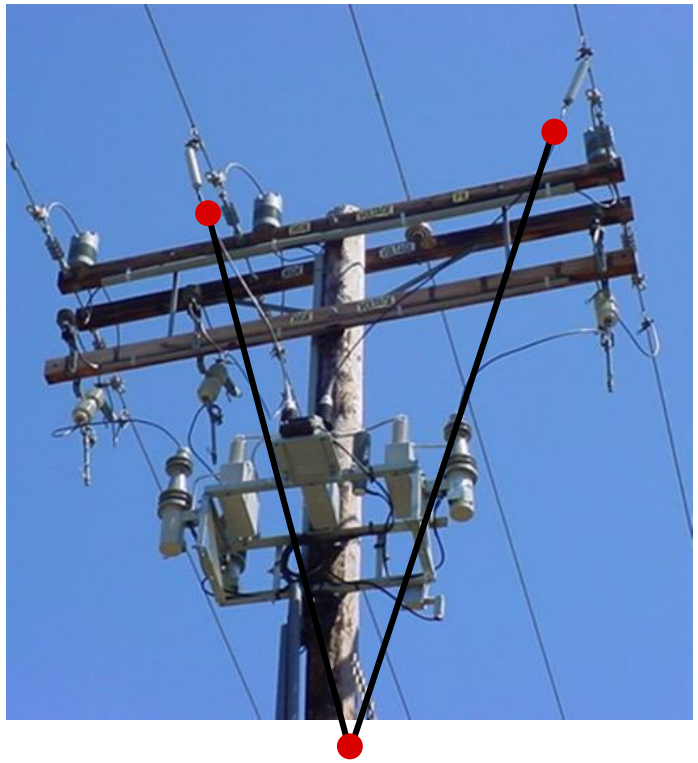
Trans-Guard SX full-range oil-submersible fuse for wet-well applications

Trans-Guard EX full-range fuse, clip-mounted with visual indicator

# Applications

## Potential transformer (PT) protection

- Full-range fuses offer multiple options for PT protection
  - Outdoor options for SCADA systems and switched capacitor banks
  - Fused elbows
- PT protection is often forgotten or overlooked; however, PTs play an important role in the reliability of the overall system
- Adding current-limiting fuses greatly reduces the effects of a PT failure by significantly limiting the energy and clearing in less than one-half cycle



Outdoor full-range fuse

# Applications

46–138 kV EXT

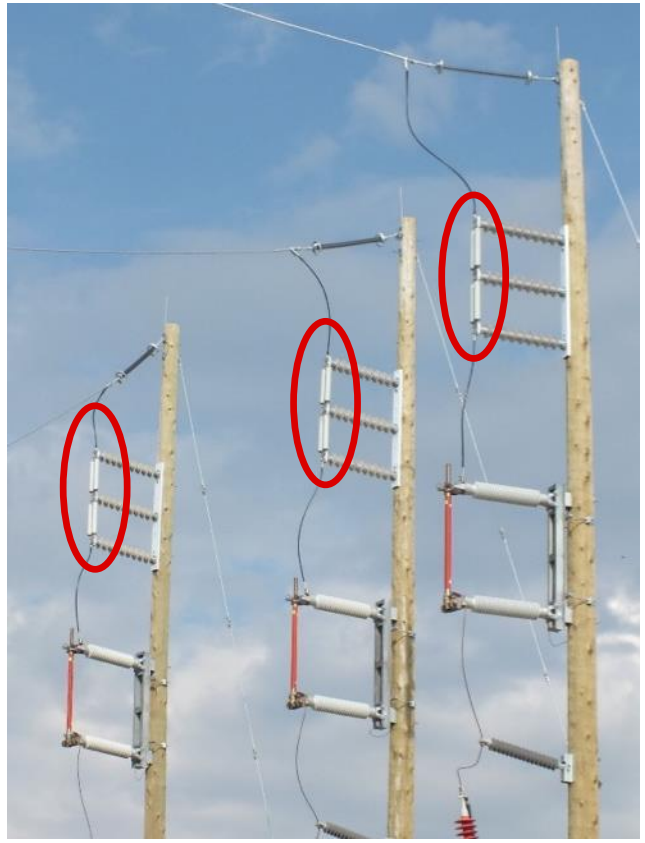
**Current-limiting backup fuses for 46–138 kV substation applications**

- Previously limited to 34.5 kV systems
- Increased maximum interrupting capabilities over traditional stand-alone expulsion fuse up to 100 kA
- Drastically decreases $I^2t$ let-through (energy) during a fault

# Applications

## EXT substation fuse example

- Combine with expulsion-style power fuses to maximize protection
  - Maximizes safety
  - Minimizes equipment damage
- Offers higher interrupting capabilities than a stand-alone expulsion fuse
- Match-melt coordination ensures expulsion fuse drops open to provide visual indication



# Hi-Tech current-limiting fuses

Standards

# Standards

## IEEE/ANSI C37.40

Fuses are covered by the IEEE/ANSI C37.40 family, which defines, specifies and provides testing requirements for expulsion and current-limiting fuses.

IEC standards are similar; however, they assume effectively grounded circuits and are often tested at different voltages, lower than actual nameplate voltage.

Standards require various tests, which include:

- Maximum interrupting capabilities
- Maximum application temperatures and maximum energy scenarios
- Minimum interrupting capabilities

# Hi-Tech current-limiting fuses

Products — features and benefits

# Products — features and benefits

Trans-Guard oil-submersible OS (HTSS)

| Features | Benefits |
|---|---|
| **High current ratings available in a single fuse body** | Minimizes the cost and physical space associated with paralleling two fuses to achieve the desired current rating |
| **Rigorous testing to meet ANSI/IEEE standards** | Internal quality requirements, including 100% physical inspection, resistance measurements and helium mass spectrometer leak testing |
| **Rugged machined brass end caps** | Greater fracture strength for lasting fuse integrity |
| **High fault current interrupting capability** | 50 kA symmetrical for most ratings |
| **Higher-rated maximum voltage designs** | 10 kV, 17.2 kV, 25.5 kV and 38 kV for many of the OS Shorty designs for suitability in many system applications, including wind and solar |
| **Smaller physical size** | Compact size of the OS Shorty is especially beneficial in small single-phase distribution transformers and under-oil applications |



Cut-aways on products shown here for illustration purposes only.

# Products — features and benefits

Trans-Guard full-range series

FX

EX

SX

Blown fuse indicator

| Features | Benefits |
|---|---|
| **Patented damage sensor** | Designed to significantly reduce the risk of fuse failure when subjected to an element-damaging current surge |
| **Hermetically sealed construction** | To prevent the escape of gases from the fuse during current interruption |
| **Multiple mounting styles adapt to various configurations** | Various types offered for multiple applications with the highest current ratings available in a single body fuse |
| **Machined brass end caps** | Greater fracture strength and corrosion resistance, resulting in less distortion and more secure fuse attachment in dry-well canisters |
| **Tested in accordance with the most recent ANSI/IEEE standards** | Includes requirements for short circuit testing at the manufacturer's specified rated maximum application temperature (RMAT) |
| **Optional blown fuse indicator** | Reliable indication of fuse operation with a unique design that does not affect the fuse's arcing performance or complete sealing system |
| **Full-range fuse technology** | Both overload and fault current protection for distribution equipment in one fuse:<br>**FX Series:** Dry-well canisters, livefront switchgear, deadfront submersible applications and overhead conductor applications<br>**SX Series:** Wet-well applications<br>**EX Series:** Capacitor applications |

# Products — features and benefits

Trans-Guard full-range series and elbow housing

Fused loadbreak elbow (FLR)

Trans-Guard full-range EFX-E fuse

| Features | Benefits |
|---|---|
| **EPDM molded rubber deadfront construction** | – Fully sealed and submersible<br>– Light weight<br>– Insulate, shield and eliminate exposed live parts |
| **Two-piece housing** | Easy fuse replacement |
| **Built-in voltage test points or direct test ports** | Quick and convenient blown fuse indication |
| **Full-range current-limiting fusing with 50 kA interrupting capability** | – Facilitates fusing of light-duty underground distribution systems, including sub-loops, radial taps, junctions, transformers and other equipment<br>– Rated 5 kV ungrounded to 25 kV grounded wye<br>– 15/25 kV hot-stick operable, loadbreak elbow switching |
| **Adaptability** | Easily installed retrofit to upgrade existing distribution systems using separable connectors |

# Products — features and benefits

## Trans-Guard full-range EFX fuse

Molded current-limiting full-range fuse (MCLF)

| Features | Benefits |
|---|---|
| **EPDM molded rubber deadfront construction** | – Fully sealed and submersible<br>– Insulate, shield and eliminate exposed live parts |
| **Specially designed fuse elements with built-in low- and high-current interrupting capability** | Full-range fault current protection through 50 kA |
| **Current-limiting protection with fault clearing in less than one-half cycle** | Limits the system available fault current and dramatically reduces stresses on equipment |
| **Modular construction with a center replaceable fuse section and interchangeable end fittings** | – Allows elbow connection or direct attachment to equipment-mounted bushings<br>– Flexibility of installation on junctions, transformers, cable runs, taps |
| **Type 304 stainless steel brackets and hold-down straps available** | Accommodates a wide variety of mounting arrangements |
| **Compact** | Suitable for padmount, subsurface or vault installations in submerged conditions with a fully molded and sealed fuse |

# Products — features and benefits

Trans-Guard full-range series

Molded canister full-range fuse (MCAN)

| Features | Benefits |
|---|---|
| **EPDM molded rubber deadfront construction** | – Fully sealed and submersible<br>– Insulate, shield and eliminate exposed live parts |
| **Compact** | Suitable for padmount, subsurface or vault installations |
| **Modular construction** | – Allows elbow connection or direct attachment to equipment-mounted bushings<br>– Neon voltage indicators (V2) attached to elbow test points allow quick and convenient blown fuse indication |
| **Replaceable fuse section** | Ease of fuse replacement without full removal from installation |
| **Current-limiting protection with fault clearing in less than one-half cycle** | Limits the system available fault current and dramatically reduces stresses on equipment |
| **Type 304 series stainless steel mounting brackets, and wall-mounted parking stands available** | Accommodates a wide variety of mounting arrangements |
| **Various end fittings and bushings** | Flexibility of installation on switchgear, junctions, transformers, cable runs and taps |

# Products — features and benefits

## Trans-Guard EXT

Trans-Guard EXT
external backup

Trans-Guard EXT
substation fuse

| Features | Benefits |
|---|---|
| **Superior performance** | Low total $I^2t$ let-through provides maximum protection for equipment by minimizing energy let-through during a fault; higher melt $I^2t$'s on smaller fuse ratings make fuses less susceptible to damage from current surges |
| **High fault interrupting capability** | As high as 50 kA symmetrical |
| **Small physical size** | Shorter, lighter-weight design makes fuses easy to handle and install |
| **Integral pre-assembled hardware** | Reduces installation time and likelihood of joint deterioration |
| **Durable design** | Extends outdoor life; includes machined brass end caps and filament-wound epoxy, centerless ground tubular bodies, ground and coated with oven-baked acrylic paint |
| **Broadest range of ratings** | Up to 100 kA at 8.3 kV and 15.5 kV; up to 80 kA at 23 kV; designs for 46–138 kV applications up to 100 kA |
| **Current-limiting action** | Reduces voltage dip time during a fault, improving power quality while allowing sufficient let-through current to cause the cutout fuse to melt and drop open with a minimized activation event |
| **Multiple hardware options** | Wide variety of mounting and connection options for greater flexibility in installation for overhead installations in conjunction with other low-current protection devices, including substation applications up to 138 kV |

# Hi-Tech current-limiting fuses

Hi-Tech FACT program

# Hi-Tech FACT program

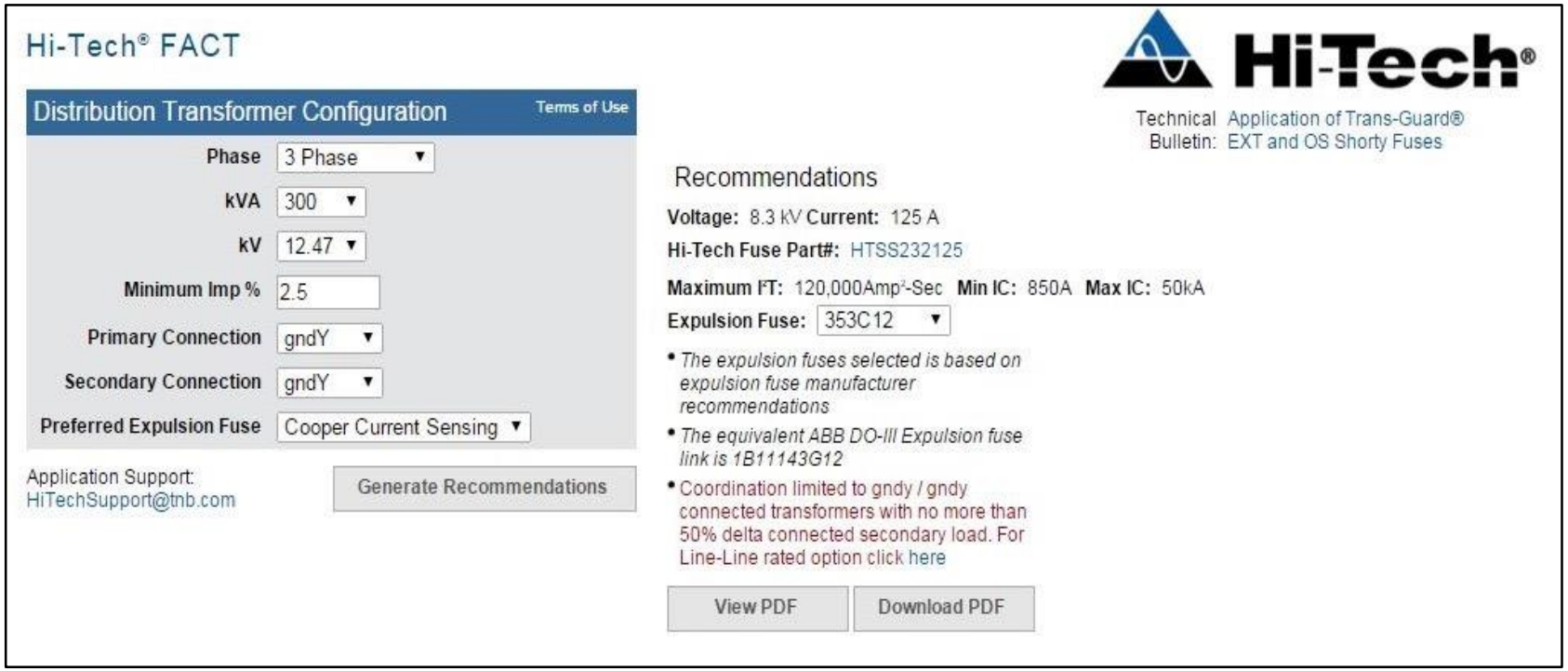
## Fuse application coordination tool (FACT)

**FACT: Distribution transformer protection**

- Online program for coordinating under-oil expulsion fuses with current-limiting backup fuses provides needed data with just a few clicks
  - User inputs transformer data and preferred expulsion fuse type
- Outputs information for proper fuse coordination in seconds, customized for the existing application
  - $I^2t$ and other useful information provided for assurance of optimal protective limits and fuse selection
  - Additional product information readily available via web-linked catalog
- Quickly provides information on the fly when it's needed for ease and accuracy of fuse specification, saving valuable time
- Live application and engineering support also available

# Hi-Tech FACT program

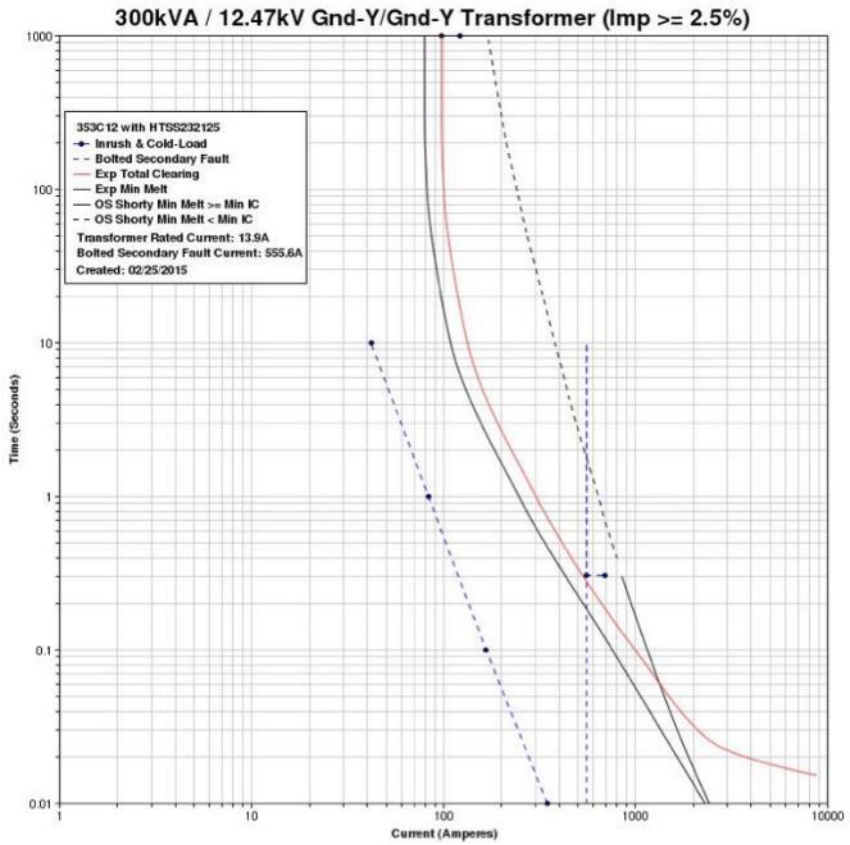
FACT input example




**Find FACT at: www.tnb.com/hi-techfact**

# Hi-Tech FACT program

TCC: Time-current curve output plot



# Hi-Tech current-limiting fuses

Concluding points

# Concluding points

## Value proposition summary

- Hi-Tech current-limiting fuses offer maximum reliability, system protection and flexibility in a cost-effective compact package
- 100% factory sealed and tested to industry standards means a quality product out of the box when it’s needed
- Provides increased safety and ability to lower system costs in order to provide better service for utility customers by preventing equipment damage and adverse failure modes
- Production in Hickory, North Carolina, means product is available domestically without risk of international delay
- Nationwide application support available when needed


ABB