A Circuit Protection Update:

When a Circuit Breaker Isn't...

By Ashley Harkness
Why do I care?

• Protection Equipment Basics:
  – Circuit Protection Issues
    • Breakers vs. Protectors.

• The Main Issue:
  – Let-Through Current

• Different Equipment Overlaps
  – Manual Motor Controllers
Circuit Protection: Protection from What?

- Overloads: Beyond intended energy use
- Short Circuit: Drastic failure
- Limit Damage
- Limit Losses

- Circuit Breakers and Circuit Protectors
What is an overload?

- Operation of equipment in excess of normal, full-load rating,
- Or of a conductor in excess of rated ampacity
  - sufficient time to cause insulation damage

- Note: A fault, such as a short circuit or ground fault, is not an overload.
Heat and Current Flow

Normal Current Flow

Excessive Current Flow
Conductor Heating

• Example:
  – 15 Amp Motor
  – AWG 12 Wire
  – Lock Rotor 90A
  – OVL Trip: 20 Sec
    (1200 cycles)
  – Conductor Overheats.
  – Insulation fails
Conductor Damage

Good Insulation

Insulation Affected by Heat
What is a Short Circuit?

• A low impedance path with limited current restriction
  – Limited by circuit impedance
  – Can cause arcing damage
  – Drastic Failure: Fire and Flame
  – Collateral Damage and Loss
Conductor Short Circuit
The Main Issues:

- Let-Through Current
- Component Current Interruption Ratings
Current “Let-Thru”

- Contacts Opened
- Trip Activated
- Overcurrent Sensed

$IP$

$T$
Available Current

• How Much Current?

• At a machine input terminal…
Available Current, 480 V

- 500 MVA at source
- Mixed Devices
- Available at bottom: 20,300 Amps
How Do We Protect Circuits?

- Circuit Breakers
- Circuit Protectors
- Other type Protectors.

- All break the current path.
Circuit Breakers

• Opens and closes a circuit
• Manual Operation
• Open Under Fault Without Damage
• In the US, in accordance with UL 489
• Purpose: Protect wires!
• Fault Withstand >20 kA
Circuit Breakers

• Branch Circuit Rated
  – Larger size:
  – 600 Volts
    • 1 Inch = Air
    • 2 inches = Surface
Circuit Breakers, More

• UL 489: Defines Molded Case Circuit Breakers (MCB)
  • Service Entrance Protection
  • Service Feeder Protection
  • Branch Circuit Protection
  • Motor Protection
  • Disconnecting Means
Circuit Breakers, More

• Inverse Time Response Curve
• Instantaneous Interrupt
Supplementary Protectors

• Supplements Circuit Breakers, UL 1077
• Common Characteristics
  – Open and close a circuit
  – Manual Operation
  – May or May Not Suffer Damage
• Smaller size: 600 VAC = 3/8” Air; ½” Surface
• Restricted Fault Current: <10kAmps
• Not Branch Circuit Protection, Restrictions
• Purpose: Protect Load
Supplementary Protectors, More

- The supplementary protector provides:
  - Equipment protection
  - Local protection near (on) the device
  - Isolation of the individual load
  - Is “in addition” to the wiring protection
- Must come after Branch Circuit Protectors
An Example of the Difference

- Residential Application:
  - 15 Amp CB protects Residence Wiring
  - Sink Disposal “Protector” 2 Amps
  - Jammed motor is protected
  - Result:
    - Clear Jam,
    - Proceed with Thanksgiving Dinner
What do they look like?
Tripping characteristic F

Tripping characteristic H
## Approvals

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Experience in Japan

• Main Breaker, 22KA feeding Circuit Protectors, 5 KA
  – Located next to each other.
  – Prove it!
  – They were seeing 15,000 Amps!
The Result:

• Checked Every Conductor vs. Fault Current
• Checked Every Device vs. Fault Current rating
• End Result:
  – All Circuit Protectors in Power Circuit were changed to Circuit Breakers
Different Equipment Overlaps:

• Manual Motor Controllers, UL 508
What is a Manual Motor Controller

• Manual motor controllers (UL-508, Part III) are devices that provide a means of controlling (switching on and off) a motor.

• Manual motor controllers may be applied in group applications per Article 430-53 of the National Electrical Code.
Group Installations
Advantages

STANDARDS & APPROVALS
- IEC 60947-1, 60947-2, 60947-4
- DIN VDE660T 100 / 101 / 102
- UL 508 / CSA 22.2
- UL, cUL Listed
- CE Marked

INSTALLATIONS

Individual Installation

Group Installation

Combination Installation
Manual Motor Protector Curves
What Does the Sales Literature Say?

• “…drastically limit let-thru energy..”
• “Manual Motor Controller and Supplementary Protector”
• “Minature circuit Breaker”
• “Motor Protection Circuit Breakers”
But some are clear

- Adjustable trip economy Manual Motor Controllers
- Obviously a switch
- This an answer to your problem
Advantages

• Smaller
• Cheaper
• Added protections
• Group Ratings
• Local control
• Cross of European and US
What do they Look like?

Thermoplastic housing resists tracking; withstands impact.

Two-point contact arm design reduces overall unit size, provides more enclosure space.

Heavy-duty, zinc-plated strap resists corrosion; two rolled-brake rivets secure the strap to the housing to avoid field tampering.

Two oversized silver alloy contacts withstand years of use, improve heat dissipation by distributing arc energy.

One-piece contact carrier constructed of glass-reinforced thermoplastic ensures long-lasting "make and break" performance.

Exclusive, ready-to-wire external screw-pressure-plate back and side wire capability for easy installation with solid or stranded wire.

Oversized #10 terminal screws increase contact with wire and increase torque limit. Angled screw heads for easier access.
What do they Look like?

Switches combine motor controller and disconnect.

June 17, 2003 -
Circuit-Lock®
motor controllers
are UL 508 listed
to comply with both controller and disconnect requirements of NEC. Positioned between load center and motor, switch allows user to safely terminate circuit power at motor for servicing without shutting down entire line. Disconnects are rated to withstand 10,000 A high fault short circuits. Units are available as component switch or pre-assembled into NEMA-rated enclosure.
What do they Look like?
Japanese Experience

- Handed a Fuji Manual Motor Controller
  - Replace a Circuit Breaker in a Feeder Circuit
Not so Fast

• NEC Article 430-81(a), defines a Motor Controller as “…any switch or device that is normally used to start and stop a motor by making and breaking the motor circuit current.”

• NEC Article 430-109 (a)(6) states: “Listed manual motor controllers additionally marked ‘Suitable as Motor Disconnect’ shall be permitted as a disconnecting means where installed between the final motor branch circuit short-circuit and ground-fault protective device and the motor.”

• UL 508A, paragraph 30.3.3 states: “A manual motor controller marked ‘Suitable as motor disconnect’ shall be installed only on the load side of the branch circuit protective device.”
But Ashley-san....

- The MMC looks like a Circuit Breaker
- Has overload capabilities like a Circuit Breaker,
- And even talks like a circuit breaker...”

- But has a 5kA interrupt capability
Type F Motor Starter

Photo: The photo shows the construction difference between a Type F Motor Starter and a Type C Motor Starter. The Type F Starter is designed with larger electrical clearances on its supporting supply terminals.
Type F Combination Starter

• Eliminates the need for Branch Circuit Protection

• Combinations must be UL Approved
For Motors, The Reality:

General Purpose UL1077 Supplementary Protector

Motor Rated UL1077 Supplementary Protector

UL508 Manual Motor Controller
How it Comes Together
In Summary

• Circuit Breakers are Branch Circuit Protection
• Circuit Protectors are for Load Protection
• Motors can be protected in different ways
• Fault Current and Interrupting capability must be evaluated