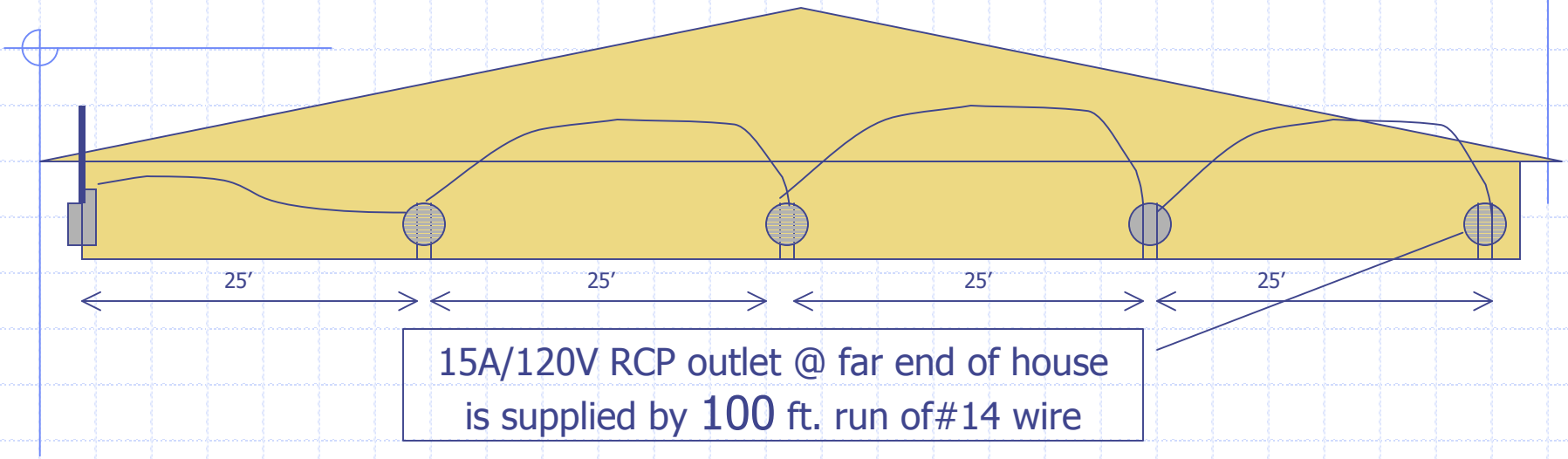
Is Voltage Drop just a "Design Issue"?



There is no limit in the NEC as to how far a 15 or 20A/120V branch circuit can be run from a service to supply an outlet. This would be merely a "design issue", except that recent field test data shows that beyond a certain point, circuit breakers may not consistently provide adequate protection if a ground-fault or short-circuit occurs at an outlet served by a long run of cable.

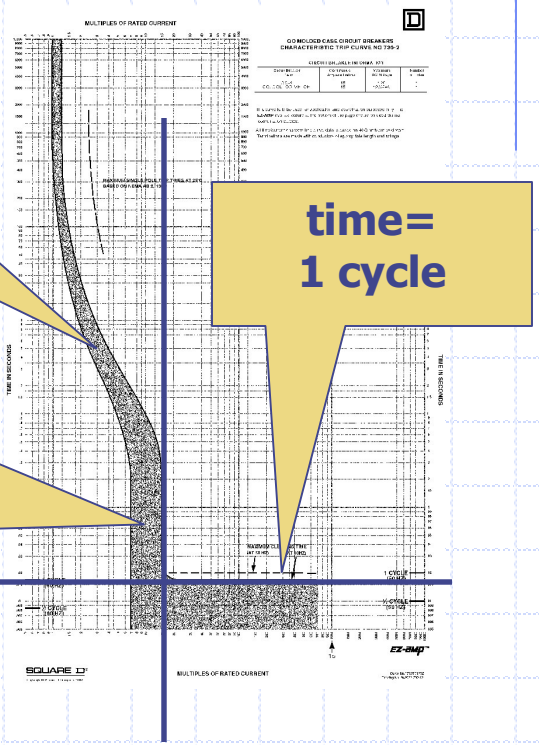
Thermal/magnetic circuit breakers…

Thermal Range: Intentionally delayed response:

- Always engaged
- Time shortens as overcurrent increases
- Intended as protection against overload

Magnetic (Instantaneous) response:

- Intended to provide instantaneous protection from short-circuits and ground-faults
- When engaged, magnetic response clears circuit in 1-cycle (1/60th of a second) or less



"Magnetic Tripping Characteristics:

The lower right portion of each trip curve displays the magnetic tripping response of the circuit breaker. This takes place when overcurrents of sufficient magnitude operate an internal magnetic armature which unlatches the mechanism. Magnetic tripping occurs **with no intentional time delay**." [NOTE: formatting added]

-Schneider/Square D- Characteristic Trip Curve #730-2: QO 15A/1-pole

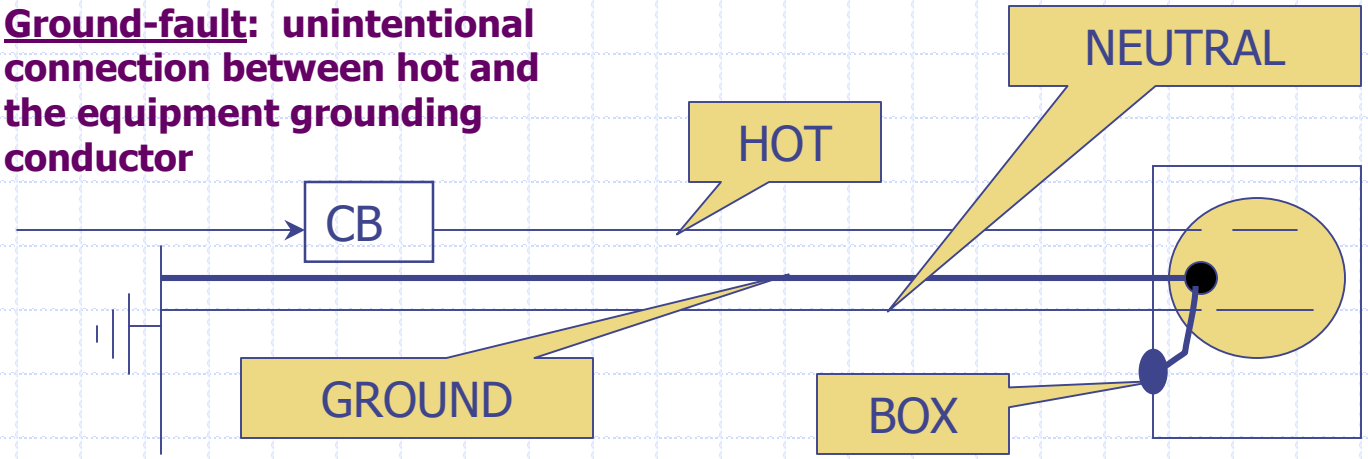
The NEC requires instantaneous breaker response to ground-faults, but the requirement is unenforceable…

"Electrical equipment … shall be installed in a manner that creates a permanent, low-impedance circuit facilitating the operation of the overcurrent device [underlining added] ….

By the use of the phrase, "…facilitating the operation of the overcurrent device…", CMP-5 intends that a thermal/magnetic circuit breaker must respond magnetically to a fault to the equipment-grounding conductor of the circuit.

-Mike Johnston, Chair, CMP-5 re intent of 250.4(A)(5)

Ground-fault: unintentional connection between hot and the equipment grounding conductor



Short-circuit: unintentional connection between circuit conductors

The Problem…

- Short-circuit field test data reveals that the magnetic response in the circuit breaker protecting the majority of installed 15A/120V receptacle outlets is not triggered by a short-circuit or ground-fault, leaving those outlets with **thermal overload protection only, in violation of NEC 250.4(A)(5) and other NEC requirements.**
- Among those outlets in which a thermal mechanism is the breaker's only available response to a short-circuit or ground-fault, **nearly 1 in 5 circuits incur possible insulation damage*** when a short-circuit or ground-fault occurs, creating a potentially unsafe wiring condition in those circuits.

*ICEA, P32-382, Short-Circuit Ratings for Insulated Cables

Substantiation: Test Data

Number of outlets in sample:		1017
CIRCUIT BREAKER RESPONSE SUMMARY DATA		
MAGNETIC RESPONSES (<=1 cycle):	**43%**	**438**
HIGHEST I2T VALUE OF ANY MAGNETIC RESPONSE IN SAMPLE: (amps-squared-seconds)	**20,358**	
THERMAL RESPONSES (> 1 cycle):	**57%**	**579**
POTENTIAL INSULATION DAMAGE: **# THERMAL RESPONSES > ICEA limit** (47,000 amps-squared-seconds = ICEA limit on I2T heating for #14 cable*)	**18%**	**104**
INSULATION DAMAGE: **Highest recorded I^2T conductor heating value**	**88,804**	

International Cable Engineers Association: Publication P32-382 (revised 2007), "Short-Circuit Characteristics of Insulated Cables", latest revision approved by the American National Standards Institute (ANSI), June, 2007.

Bussman study* of engineering research... ICEA, Middendorf, Soares and Onderdonk

INSULATION CONDITION	CONDUCTOR HEATING	CONDUCTOR HEATING (DEGREES C)	STUDY	TEST DATA RESULTS (I^2T)
NO DAMAGE	47,000 (AMPS ^{2} SEC)	150 C	ICEA**	10% > 47,000
WIRE LOOSE UNDER LUG	94,000 (AMPS ^{2} SEC)	250 C	SOARES	1 @ 88,000
½ DIELECTRIC STRENGTH (INSULATION UNSAFE)	150,000-200,000 (AMPS ^{2} SEC)	NOT GIVEN	MIDDENDORF	NONE
COPPER WIRE MELTS	250,000 (AMPS ^{2} SEC)	1083 C	ONDERDONK	NONE

*Cooper Bussman conducted a study in 2002 entitled, "**An Investigation of the Use of 16 and 18 AWG Conductors for Branch Circuits in Industrial Machinery Built to NFPA79, 2002",** by Joe Shomaker and Todd Lottman.

**The Insulated Cable Engineers Association (ICEA) standard P-32-382 provides a standard physics formula for determining the short-circuit withstand capability of insulated copper conductors. The ICEA formula is the most common method used to determine conductor withstand ratings in the industry; it is referred to in several IEEE standards cited in the Bussman study.

Fortunately, there is a Simple Solution …

Proposal #2-193 for the 2011 NEC:

210.19 Conductors- Minimum Ampacity and size

(A) Branch Circuits Not More Than 600 Volts.

(5) Permissible Voltage-Drop. The circuit conductors of a 15 or 20-ampere/120-volt branch circuit shall be sized such that voltage-drop measured at the rated ampacity of the circuit shall be 5% or less at any outlet.

Substantiation: Fire Data…

"One-third of 2002-2005 non-confined home structure fires involving wiring began with ignition of wire or cable insulation."

HOME STRUCTURE FIRES INVOLVING ELECTRICAL DISTRIBUTION OR LIGHTING EQUIPMENT
National Fire Protection Association
March 2008