Engineering Ethics Cases with Numerical Problems

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Electrical Engineering Case 12

Toaster Short Circuit

Authors: Suggested Courses:

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Level:

Sophomore

I. Narrative

Jane is a recent graduate engineer working for an electrical consulting company (Eleck Inc.). She is given the job of laying out the wiring for a new home. In particular, she must specify the circuit breakers that protect the circuits to the wall plugs of each room and the ceiling lights. Normally these circuits are wired with AWG #14 wire and are protected by 115 V/ 15 A breakers.

A co-worker, Jerry, who is a mechanical engineer tells her that she should specify 115 V/ 20 A circuit breakers because each circuit then could handle higher current appliances or more appliances at a time. But the house will be wired with # 14 wire which has a continuous current rating of 15 A. Jerry's reaction to this is "Oh, forget that the house will be wired with #14. The overload caused by the appliances will only last a few minutes and a 20 A breaker will provide adequate protection." Subsequently, the house was built with the #14 wire installed in the appropriate circuits and protected with 115 V/ 20 A circuit breakers as specified by Jane.

Two months after the house was built and the family moved in, a fire occurred in the house causing $75,000 worth of damage. The fire marshall's report stated that the fire was caused by an electric toaster having a short circuit in it. The report also stated that the short circuit current in the toaster was estimated to be 550 A and lasting for 10 seconds. The important parameters in causing an electrical fire is the energy from the electrical short and this energy is related to i^2t. The i^2t for this short circuit is approximately 3×10^6 amp^2-seconds.

($i^2t = 550^2 \times 10$ seconds $= 3 \times 10^6$ amp^2-seconds)

The specifications for circuit breakers include:

Circuit voltage

Continuous current

Overload currents in terms of i^2t

Maximum short circuit fault current

For the 15 A breaker, the i^2t is 2 x 10^6 amp^2-seconds and for the 20 A breaker the i^2t is 4 x 10^6 amp^2-seconds. Note that the tripping time of the breaker depends on this i^2t value. When the overload currents are larger, the time to trip the breaker is shorter. Conversely, when the overload currents are smaller, the time to trip the breaker is longer.

II. Numerical and Ethical Problems

1. Was Jane justified in specifying the 20 A breaker rather than the 15 A breaker for this house? Explain your reasoning.

1. What are the ethical responsibilities of Jane and Jerry in regard to this accident? Which parties will be liable in this case? Please refer to the NSPE (or other professional society) code of ethics for reasons supporting your arguments.

III. Solutions to Numerical and Ethical Problems

The i^2t for the toaster short circuit, based on estimates is: i^2t= (550)2(15_ = 4.5E6 $Ampere^2$-seconds. Due to the rough estimates involved, only one significant figure is used, thus **5E6 $Ampere^2$-seconds.**

This corresponds (approximately) to the rating of a 20 Ampere breaker. If a 15 Ampere breaker was used, the i^2t rating of 2E6 $Ampere^2$-seconds would have reduced the burning time of the 550 Ampere short-circuit current to:

For the 20 Ampere breaker we compute:

This is a significant increase in the heating time, and could be the difference between combustion occurring or not, relative to the study cases.

Note that it may have been the case that the 20 Ampere breaker could have remained closed for an indefinitely long time. This is so because the i^2t corresponding to the toaster short circuit was estimated to be marginally close, but less than, the 20 Ampere breaker 1^2t rating. Because of manufacturing variability, the true i^2t of the breaker is subject to a tolerance, say 10%. And note that the fire marshal's estimates are necessarily imprecise. Indeed, one should include some estimate of the probable error, such as "17 seconds 20%."

The shorter heating time attendant to using a 15 Ampere breaker may have prevented a fire in the toaster and the subsequent house fire.

It was the ethical responsibility of Jane to check the National Electrical Safety Code (NESC), as well as local building codes, and to determine whether it is justifiable to specify a 20 A breaker rather than a 15 A breaker

Jane should have investigated the specifications of each breaker and determine whether there are any problems such as i^2t overload. She violated the National Society of Professional Engineers Code of Ethics for Engineers Fundamental Canon No. 1, and Rules of Practice No.1, which deal with the safety, health, and welfare of the public.[2]

Jerry violated the 2nd Canon and the 2nd Rules of Practice which demands that engineers shall perform services only in the areas of their competence.

It must be noted that Eleck Inc. is ethically responsible, and very likely legally liable, for the fire. A. Licensed professional electrical engineer must sign and seal drawings, specifications, etc. having to do with public safety. If Jane was not a P.E. qualified to do electrical power engineering, a P.E. must supervise and sign/seal the work. The P.E. responsible for the work would very likely have their P.E. license suspended, or possibly revoked, because of negligence. Additional penalties may be administered by the state entity responsible for P.E. licensing.

The mistake is a flagrant one because the NESC Code requirement of a 15 Ampere breaker is fundamental and well known in the electrical contracting trade, and by electricians and building inspectors. These individuals also may share culpability here. Although not stated in the problem, Eleck Inc. would need a contractor's license to perform the indicated services. Thus, they would be in jeopardy of losing the license, or at least having it suspended.