-----Original Message-----
From: Steve Snyder
Sent: Friday, October 03, 2003 8:38 AM
To: Steve Snyder
Subject: Re:x/r ratio

I received some feedback from Ramsis Girgis concerning WG item 49, which is a request to re-evaluate the x/r values used for system impedance when it is not specified, as it pertains to short-circuit testing. Ramsis and the folks at ABB have researched this topic, and have provided the following discussion. We will use this to supplement the meeting discussion in Pittsburgh.

Sincerely,

Steve Snyder

10/03/03

>>> <ramsis.girgis@us.abb.com> 09/30/03 11:20PM >>>

Steve
Here is the reference to the subject of this e mail as appeared in your minutes of meeting. I also got the fax including more information.

WG Item 49, C57.12.00 Section 7.1.5.2 Asymmetrical current used for Short Circuit Calculations. Comments received from drafts 3 and 4 ballots of C57.12.00 -2000 stated that the x/r ratio for the user's system is greatly different from the recommendations in this standard, and also differ from that used in IEEE C37.04 and IEC 56. They also do not reflect the x/r values used for radial feed systems as discussed in the IEC TC 17A and in CIGRE. The Working Group accepted the offer of Ramsis Girgis to investigate this subject in the relevant ANSI/IEEE and IEC standards. The report will be available in 4 weeks.

I did some investigations of typical range of x / r for all sizes of power transformers from 12 MVA to 800 MVA, core form and shell form, all voltage range, GSU vs Autos, range of load loss evaluation, etc. I got actual values for over 100 transformers. The result is as follows :

	Range of ratio x / r
Small power transformers	15 to 40
Medium power transformers	35 to 70
Large power transformers	40 to 125

Also, you mentioned in your Fax the following:

The ANSI Power Transformers Standards today say that if the system x / r ratio is not available it should be assumed to be equal to that of the transformer. One voting member of IEEE suggested, instead, to use a value of 17 and said that this value is used in IEEE C 37. 04 and IEC 56 (Standards for Circuit Breakers). He also said that for applications like radial feed systems, values of 22.6 , 28.3 , and 45.2 have been discussed in IEC TC 17 A (Circuit Breakers) and CIGRE. An AEP engineer commented that the values in the AEP system are x / r = 65 for all voltages, except for 345 KV where x / r = 50.

I checked with our power system experts and here is what the answer was:

On the power system, the x / r ratios are highest for generating units and transformers and lower for transmission lines. A review of the positive sequence impedance of different voltages for lines designed for high levels of power (lower resistance) resulted in the following x / r ratios for the transmission lines:

765-kV Line: x/r=21
500-kV Line: x/r=15
345-kV Line: x/r=12
230-kV Line: x/r=10
161-kV Line: x/r=9.7

As you can see, the lower the voltage generally the lower the x / r ratio. Also, lines designed for lower power ratings will have lower x/r ratios.

In a Substation with a lot of transformers or in a generating station, the x/r ratio will be fairly high. I looked at a 230-kV system and the x/r ratios were around 10 at most of the stations. Another example, in one system the 345-kV substations range from an x/r ratio of 10 near generation to 6 at the remote substations. In another system the 500-kV substations in the area of generation have x/r ratios around 35.

In summary, the substation x/r ratios can vary a lot and in general will always be less than the transformer x/r ratio since much of the short circuit contribution comes over transmission lines which have a lower x/r ratio than transformers. I would doubt that AEP has the values their engineer stated.

From above the conclusion is that the x/r ratio for transformers can be anywhere between 15 and 125, lower for smaller transformers and higher for larger transformers. For the power systems, it looks like the ratio is in the range of 10 to 20; again higher for higher voltages. It looks like the values given by Lorne were for transformers not the system.

Hope I provided enough data responding to the question.

Feel free to share this information with the WG. See you in Pittsburgh.

Ramsis