Q. **System Design**

The response to PUB-NLH-176 indicates that Hydro's Energy Control Centre (ECC) maintains a transformer loading guideline for emergency conditions with acceptable overload levels. Provide a copy of these emergency loading guidelines and confirm whether or not Hydro allows temporary overloading (without exceeding maximum hot spot temperatures) of transformers, when necessary to conduct repairs or switching necessary to minimize Hydro or Newfoundland Power customer outages or whether Hydro only allows short-term overloading of distribution substation transformers as indicated by Hydro's response to PUB-NLH-188.

A. PUB-NLH-315 Attachment 1 is System Operating Instruction – T-082: Terminal Station Transformer Overloading Guidelines. As outlined in the instruction, Hydro allows both long term (more than one hour) and short term (less than one hour) loadings above the nameplate rating. The percent overload capability is based on the ambient temperature.

Hydro is currently completing a review of this instruction in coordination with Newfoundland Power. This review will be completed by October 15, 2014.

HYDRO
THE POWER OF COMMITMENT

SYSTEM OPERATING INSTRUCTION

STATION:	General	**Inst. No.**	T-082
TITLE:	Terminal Station Transformer Overloading Guidelines	**Rev. No.**	
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Introduction

This is a guideline to be used in the overloading of major transformers in terminal stations when the situation occurs. It does not apply to generating transformers. Overloading transformers above nameplate ratings can cause significant loss of life of the transformer and may cause the transformer to fault. There are many factors which need to be taken into account in considering the amount of overload, some of which are the level of overload, the ambient temperature, the cooling medium, the history and age of the transformer, the dollar value of the transformer, the consequences of the failure of the transformer, etc. Therefore overloading should only be done where absolutely necessary and avoided where possible.

As all transformers are different with varying history, and each situation is different, a generic guideline becomes difficult but in review of the existing standards and transformer information on overloading the following procedure is considered safe and conservative and recommended.

Procedure

For longer term overloads are anticipated, greater than 1 hour, Table 1 is to be used. This table will limit the temperature rise and hot spot temperature to 110 degrees Celsius and should not cause any loss of normal life expectancy.

Long Term Transformer Overload Ratings for Loading Times **Greater than 1 Hour**	
Ambient Temperature (Celsius)	Percent Loading of Maximum Nameplate Rating
Less than 0 Degreees	120%
1 to 10 Degrees	110%
11 to 20 degrees	105%
21 to 30 Degrees	100%

Table 1

PREPARED BY:	**APPROVED/CHECKED BY:**	**ISSUED DATE:**	2003-07-18
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Procedure (cont'd.)

For shorter time overloads, less than 1 hour, Table 2 is to be used. This table will also limit the temperature rise and hot spot temperature indicator to 110 degrees Celsius and should not cause any loss of normal life expectancy.

Short Term Transformer Overload Ratings for Loading Times **Less than 1 Hour**	
Ambient Temperature (Celsius)	Percent Loading of Maximum Nameplate Rating
Less than 20 Degrees	120%
21 to 30 Degrees	100%

Table 2

When transformer overloads exceed these values or the hot spot indicator alarms then offload the transformer as soon as possible. If loading above these limits then further monitoring and appraisal of the situation must be done by on-call, operations and engineering personnel for the particular situation.

Additional Discussion

Additional discussion is contained in the attached appendix.

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APPENDIX

Transformer Loading and Hot Spot Considerations

Transformer Life Expectancy

The life of a transformer is the life of it's insulation and the predominant factor determining the expected lifetime of a transformer is the operating temperatures to which the internal windings are exposed and the duration of this exposure. The normal loading of a transformer is rated output when operated under normal service conditions and normal life expectancy will usually result when operating with a maximum hottest spot conductor temperature of 110 degrees Celsius. The hottest spot conductor temperature (maximum 110 degrees Celsius) at rated load is the sum of the average winding temperature (maximum 95 degrees Celsius) and a 15 degree Celsius allowance for the hottest spot in the winding. The average winding temperature is the sum of the ambient air temperature (maximum 30 degrees Celsius) and the peak oil rise of 65 degrees Celsius. Generally, the temperature of the transformer cooling oil will be the same as the average winding temperature but this does not include the effects of thermal lag in oil temperature rise (the time taken for the transformer oil to reach a stable temperature following a change in load). As a result, higher peak loads may be carried for a short time. Also, for this reason, the maximum oil temperature cannot be used as a single determining factor in establishing the maximum loading of a transformer.

General

Other factors which may affect the maximum loading rating of a transformer are: pressure in sealed units, oil expansion, bushings, leads, tap changers and stray flux heating as well as the thermal capability of ancillary equipment; such as cables, reactors, circuit breakers, disconnecting switches and current transformers. High ambient temperature will also affect the transformer maximum loading capability.

Operation of the transformer at a hottest spot temperature above 140 degrees Celsius may cause a thermal breakdown and consequent gassing within the solid paper insulation and oil. The presence of a gas pocket in close proximity to a high electric field may initiate arcing inside the transformer with unpredictable consequences.

The mean ambient temperature of the air in contact with the transformer radiators or heat exchangers in which the transformer will operate must be determined prior to any attempt at maximum loading since this temperature will directly affect the transformers loading capabilities.

Loading on the Basis of Short Duration Overloads

A transformer may be loaded above a peak hot spot temperature of 110 degrees Celsius for short periods without compromising the operational lifetime provided it is operated at a hot spot temperature less than 110 degrees Celsius for a prolonged period following the overload (these values may be determined more precisely if required).

<u>Short Duration Loading with a Moderate Sacrifice of Operational Lifetime</u>

When a transformer is loaded in excess of rated load for an excessive period of time there will be a loss of operational life in proportion to the length and severity of the overload. The aging of insulation is cumulative and the rate of insulation deterioration is a function of time and temperature (normally referred to as "loss of life"). However, caution must be exercised in overloading of power transformers since there may be "unknowns" beyond the control of the operator; for example, wide differences in ambient temperature between transformers, restrictions in air circulation or off – nominal performance characteristics and previous emergency loading histories. These factors may become important since a transformer may unexpectedly fail after accepting an overload due to some "unknown".

<u>Loading on the basis of the Maximum Hot Spot Temperature</u>

The temperature distribution within a transformer is non-uniform and therefore those areas exposed to the greatest temperature will experience a more rapid deterioration. It is common practice to consider the effects of the highest ("hottest spot") temperature when evaluating insulation deterioration. The transformer may be loaded by maximum hottest spot temperature and tripped through a simulated assessment of the peak hot spot temperature (since it is not possible to measure the peak hot spot directly for any given winding). In this case thermal relaying will trip the transformer if this maximum operating temperature is exceeded.

<u>The Rule of 8</u>

The thermal life of Class 105 insulation is halved for every increase of 8 degrees Celsius or conversely doubled for every decrease of 8 degrees Celsius.

> Note: Recent evidence suggests that temperature may play an even more significant role in insulation degradation and that this should be revised to the "Rule of 7".