THE TRANSFORMER - A BURNING ISSUE

INTRODUCTION

Even if that header only sometimes needs to be taken literally, but then quite spectacularly so, it should be food for thought that in the Fall of 2007, as many as three events on that issue were staged in Germany alone (IEH Hannover on September 3rd and 4th, VWEW Fulda on October 22nd and 23rd, 3rd Regensburg Transformer Symposium on November 6th – 8th), all of which drew numerous and top-rate visitors and featured speakers of comparable caliber. Even the quick succession of the VWEW conference in Fulda and the 3rd Regensburg Transformer Symposium did nothing to deter the audience's interest in either of the two events. In other words: the traditional view of the transformer as an uncritical piece of equipment which can be left to go on working without much attention has in the meantime given way to a new view of the transformer as a piece of equipment deserving and requiring the utmost attention. Marginal conditions such as age pattern, delivery situation, and political conditions have made substantial reactions an absolute necessity.

1. THE SITUATION

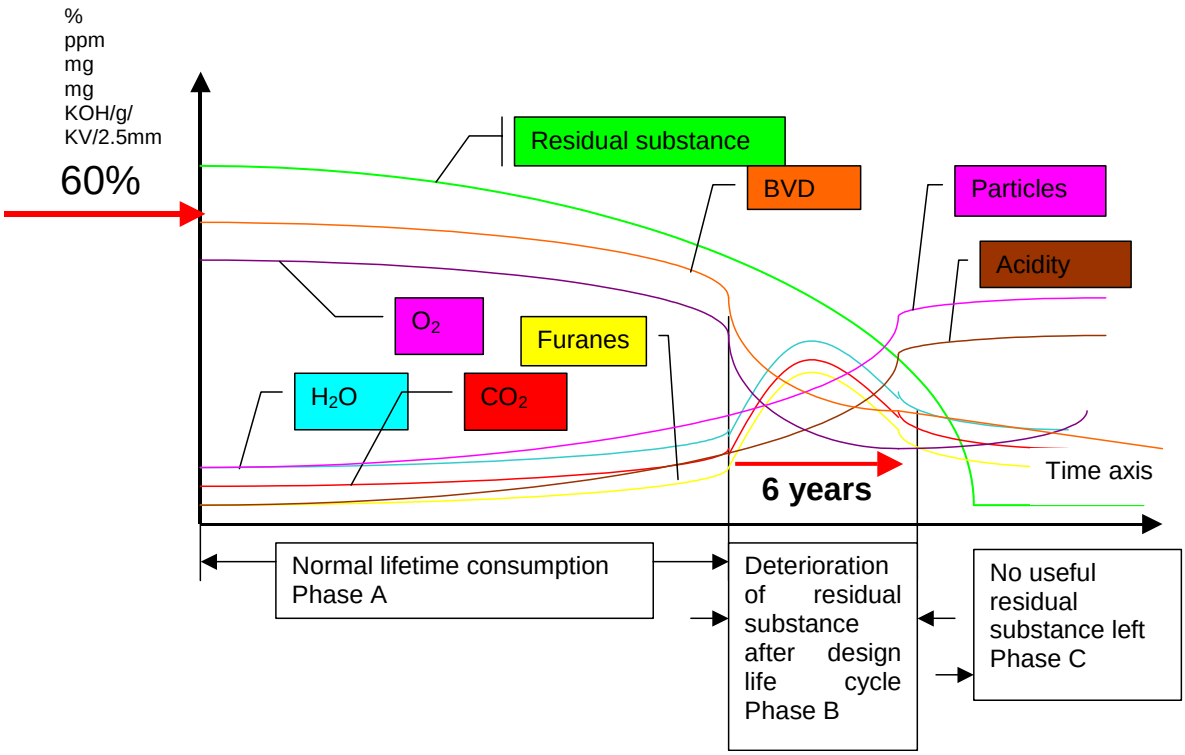
Even if it seems trivial by now, let's just recap the main factors:

- Ageing structure (age pattern), 70-80% of the inventory has exceeded its designed lifetime.
- Reduced organizational and technical capacities of the users.
- Industrial delivery times of 2 years or more.

What the above-listed factors make very clear is that a "laissez-faire" attitude is no longer acceptable if impending chaos is to be staved off at all. Without a doubt, a well-structured and target-oriented approach is vital to deal with the situation in an orderly and justifiable manner. Under no circumstances will it be possible to tackle the current situation by using the old and well-known ways, as this situation is quite unprecedented and therefore requires very new and innovative methods. The diagram shown below will make this very clear. It shows - in a very qualitative manner - that once the remaining substance is down to 60%, only a very narrow and limited time window remains for corrective and remedial actions. The dynamic decay of the substance after expiry of the designed lifetime is an established fact. The green line in this diagram shows up time and again in other publications dealing with that same issue. The exponential course of the substance decay shown here signifies that the overall time window still available for orderly action is actually much shorter than generally believed. The stance popular until now, i.e. an attitude of 'wait-and-see' until the actual appearance of a failure, is no longer valid in view of this substance decay course, since any failure will translate into a total transformer failure as the transformer will no longer contain any reusable substance!

A very different course of action is therefore of the essence: it will be necessary to determine the salvageable residual substance of the members of a population, and to coordinate conservation and necessary replacement through integrated planning and scheduling. Obviously, this planning and scheduling will have to be long-term and allow the implementation and use of all options available.

FIG. 1: THE 60% / 6 RULE



The following diagram is based on the presumption of typical populations with a homogeneous procurement age:

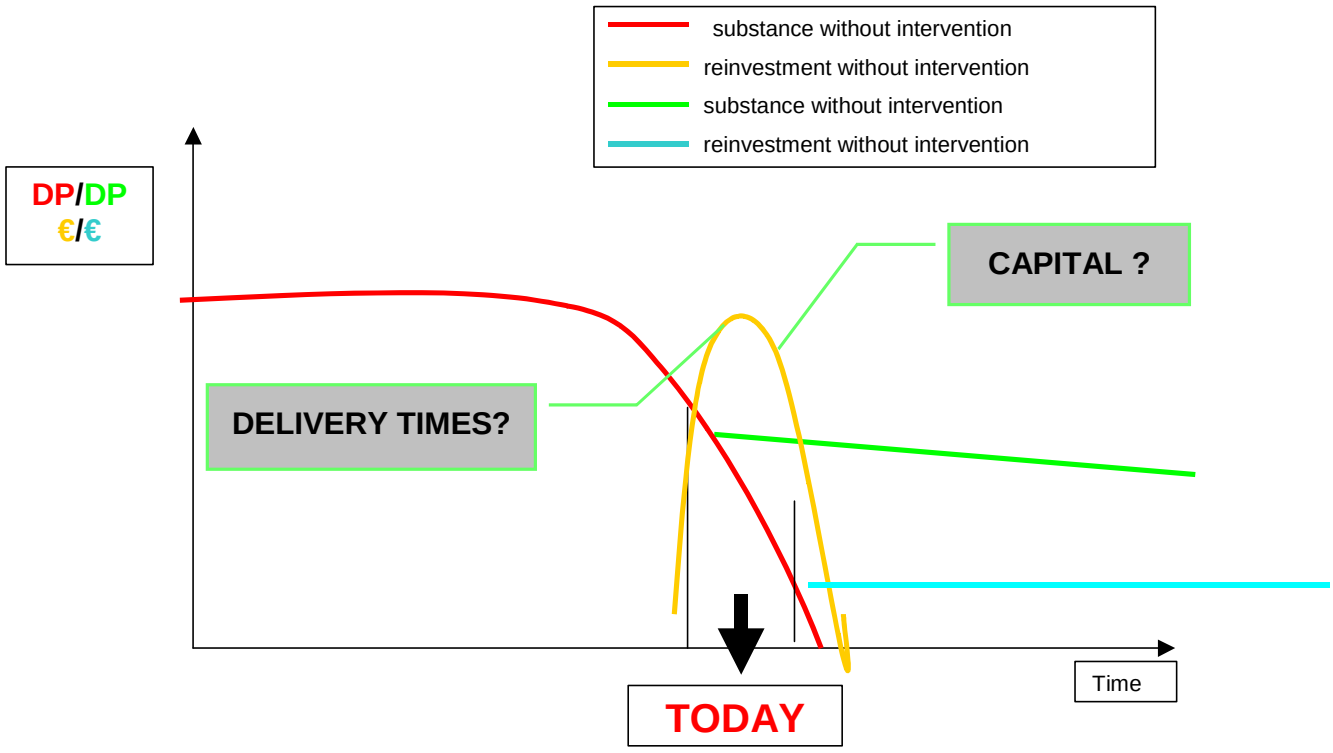


Fig. 2. Procurement situation and simultaneity factor of the failure probability

What is shown here is that the high procurement simultaneity of some 40 to 50 years ago has in the meantime led to a failure-probability simultaneity of identical magnitude, which will be impossible to cope with both financially and organizationally, without adequate countermeasures! As a " rule of thumb", let's say that 60% of substance equals 6 more years of reliable operation. As with all generalizations, this rule of thumb, although most likely incorrect for individual cases, gives a very realistic reflection of the actual situation!

2. SUBSTANCE DETERMINATION

The term "substance", introduced earlier by the author in lieu of the very relativistic and rather elusive term "lifetime", has become widely accepted for obvious reasons. As shown in Fig. 1, there is no linear correlation between substance and lifetime.

With astonishing consistency, authors are classifying the substance of transformers into four or five categories. For a change, we decided to use the diagram of a British company (EA-Technologies) who, independently of the author, are also estimating the time window until final substance destruction at 5 – 6 years.

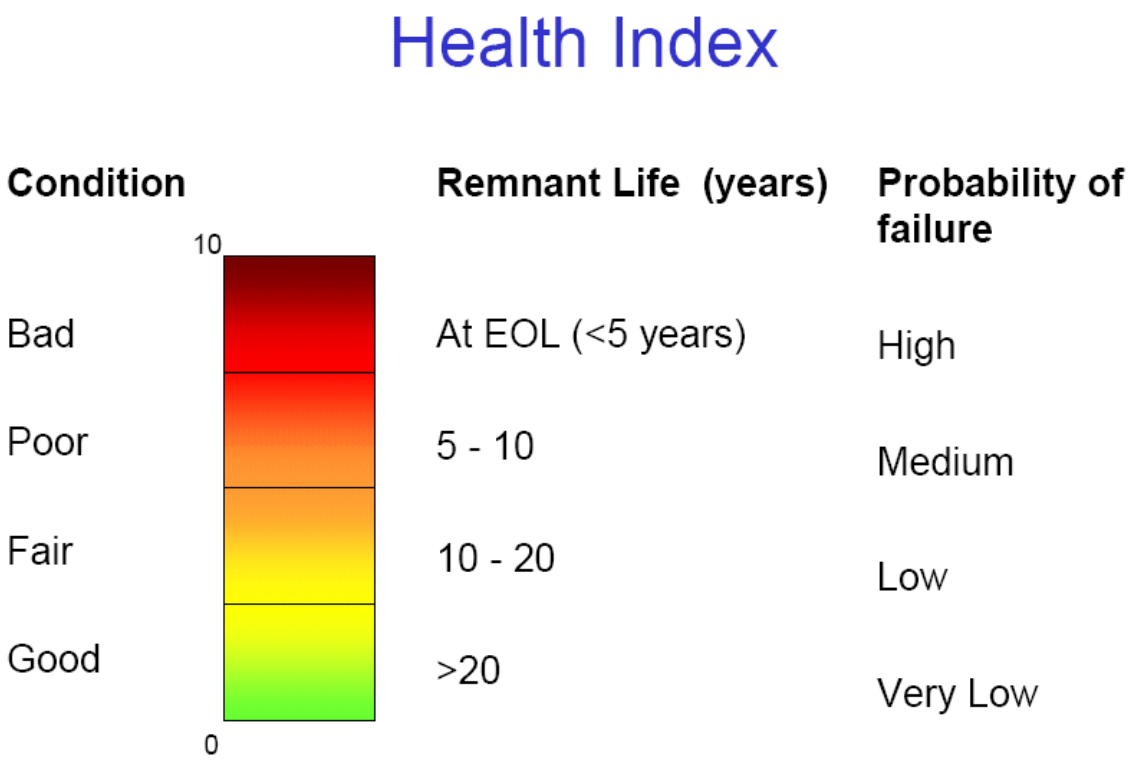


Fig. 3. Health Index according to Anne McIntosh of EA-Technologies

Although it may seem unsatisfactory that there isn't a more precise model than the classification in 4 to 5 categories, let us please remember that even this classification model is true progress and not to be sneered at if it gives the user a valid tool for classifying his population.

3. DATA COLLECTION

During the past few years, measuring and monitoring methods have proliferated and improved at an almost explosive rate. As a result, we can nowadays avail ourselves of a wide range of solutions adapted to virtually every application.

For example, small monitoring systems perfect and economical for the medium (transformer) performance range are already available in the 10,000-Euro price category. Sophisticated measuring systems for large transformers have been available on the market for some time. Even systems for measuring the mechanical integrity, "FRA, SFRA“, for the water contents such as FDS, PDC or combinations thereof, or for partial discharge measuring, all under field conditions, as well as devices for measuring the other transformer parameters, are available on the market, hence ensuring that the necessary data can be obtained at adequate accuracy and tolerable expense. There are even online gas monitoring systems on the market which allow the assessment of gas contents as well as a number of further assessments. When selecting such a system, it is important to make sure that it is capable of registering atmospheric gases, as the usefulness of this technology would be considerable compromised without these data.

Another indispensable feature of such systems is a clear and demonstrable permanent measuring stability. The nitrogen reference is equally indispensable for the assessment of the data obtain, whereas oxygen resaturation on one of the most powerful methods for assessing the ageing condition of a transformer. The cost-benefit ratio of such state-of-the-art systems will only be positive if they are considered not only as a replacement of the lab technology, but if they are used and appreciated for the options and possibilities they offer in addition to these. The necessary monitoring and assessment of overaged transformers is no longer feasible without online technologies.

4. FAULT DETECTION VS. SUBSTANCE ASSESSMENT

For most users, fault detection is still the number-one method of choice. In view of this fact it is even understandable that a lot of users feel that the classic methods, such as the ratio criteria of DGA etc., are perfectly adequate and that no new methods are necessary. However, the established methods have been created for fault detection and are therefore barely adequate for the new task, i.e. substance assessment. This task, i.e. substance assessment, is extremely urgent and indispensable for users, because it is the only way to planning reliability, i.e. to achieve a regulated way for operating overaged populations. Undefined operation until complete destruction of the equipment is simply not an option, not only because of the sometimes spectacular and severe side effects, but also because of the simultaneity factor shown in Fig. 2, which, in case of a relatively homogeneous procurement age, will lead to an equally homogeneous failure probability.

Hence the importance to determine the substance structure of the populations and to implement the results in the user’s long-term planning. It isn’t very helpful to use the basically outdated established statistics which, for instance, attribute tap changers with a high potential for errors while considering the issue of insulation a side topic. It is a known fact that these statistics are based on obsolete tap-changer technologies on the one hand, and the then much younger transformer populations on the other. The failures in the overaged insulations are bound to rise considerably and would most likely also shift the statistics, if only they were accessible. Incidentally, the issue of up-to-date and generally accessible error statistics was one of the major requests voiced during the Regensburg event (at the "World Cafe").

5. THE WORLD CAFE IN REGENSBURG

Here, the event’s participants were given the opportunity to giveactive "feedback". Without a doubt this feedback will also be of valuable use for other events.

One of the most central requests, or one of the most obvious deficiencies, whichever way you look at it, is the lack of exchange of experiences. Whereas some requested a generally accessible database at least for Europe, others generally opted for an exchange of experiences among users, even – and this seems very important – with regard to equipment as yet inconspicuous.

Another important issue which is likely here to stay is that the technical aspects should not be placed second to purely monetary aspects. This issue definitely needs to be discussed further.

Another peculiarity noted: obviously, given the vast amount of information available, it never became quite clear to the users looking for instructions exactly how to proceed after the acquisition of the data.

What was also sorely missed, both at the events and elsewhere, was the presence of the transformer manufacturers, including an outline of their innovations and the introduction of new technologies, both in terms of insulating fluids or solid insulating materials, or improved long-term stability.

Another of the issues raised dealt with the possibilities for monitoring cast-resin transformers, which may generally also include distribution transformers (see Chapter 6).

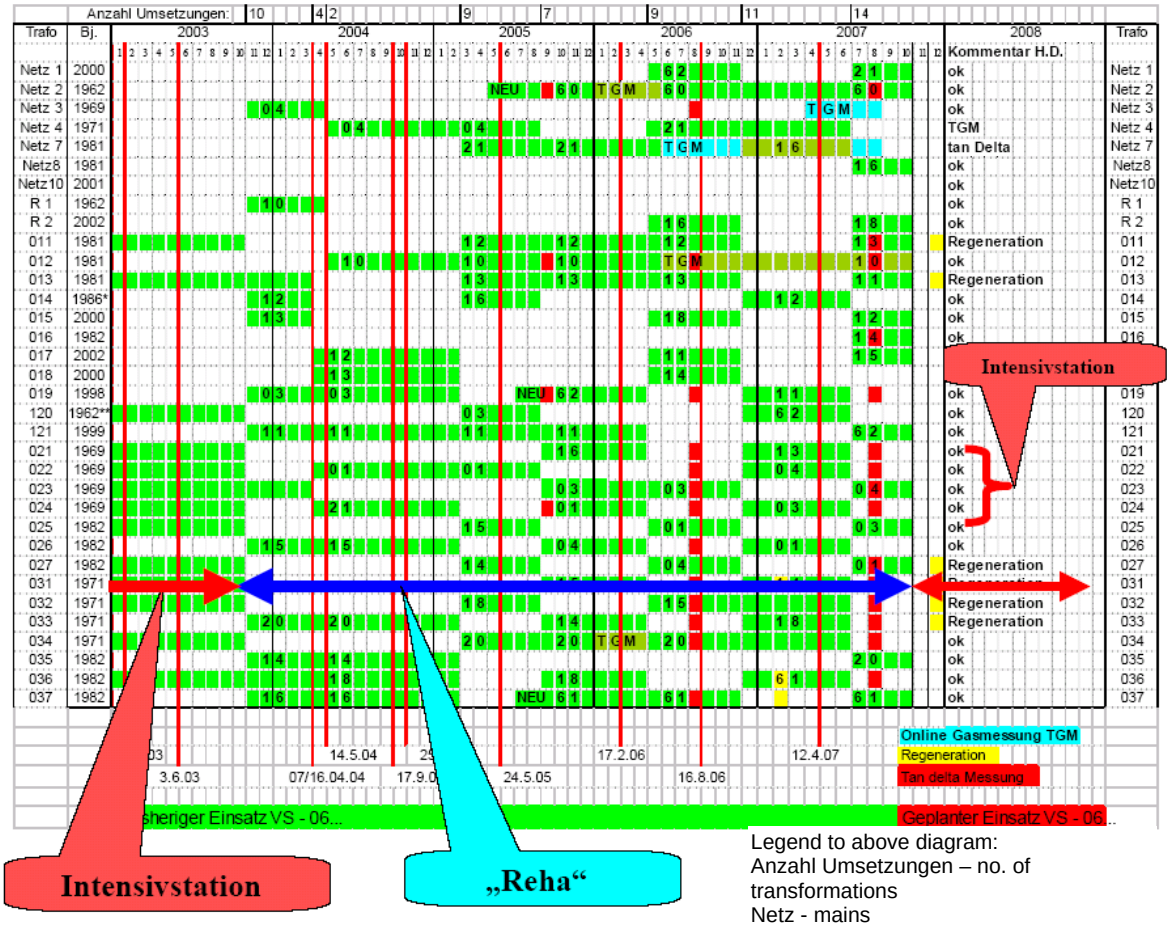
Another often-raised request concerned a standardized Standard Operating Procedure for status assessment and the resulting course of action, although EN 60422, which was also mentioned in that context, should probably be considered more of a daunting example, at least for a basically desirable European standardization specification.

6. EUROTECHCON CHESTER UK

The final and concluding presentation was rendered by EUROTECHCON of Chester UK. What became obvious once again is that the problem is the same all over the world. EUROTECHCON come up some very interesting approaches, such as systematizing the issue with programs like SAP. Another very memorable approach to economic monitoring, even of the distribution level, with state-of-the-art measuring systems was presented by NIE of Northern Ireland. They demonstrated, very convincingly, how it is possible to integrate this otherwise totally neglected area into a sensible general transformer management system.

7. SUBSTANCE CONSERVATION

What was not voiced with adequate clarity, however, was the fact that status assessment needs to be followed by bona-fide effective measures . We couldn't help the impression that the user had gotten somewhat stuck in the data acquisition phase without being fully aware of the consequences.



Legend to above diagram:
Anzahl Umsetzungen – no. of transformations
Netz - mains
Intensivstation – intensive care
Reha – rehab
Gasmessung – gas measurement
Geplanter Einsatz – planned intervention

Fig. 4 Ongoing population management

Costs for conservation of the existing transformers, calculated for 5 years.

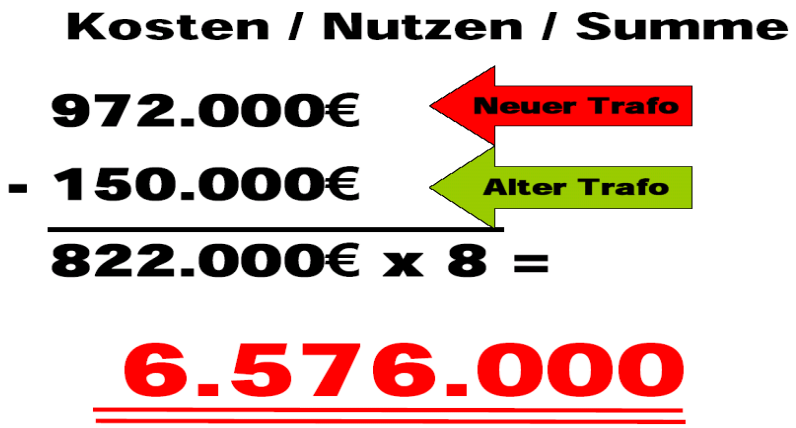
Ergebnis	-24.000	-27.600	-30.688	-33.223	-35.161	-150.672

Results:
Difference:

Costs for procurement of new transformers, calculated for 5 years.

Ergebnis	-166.667	-216.667	-236.667	-246.667	-256.667	-1.123.333
Differenz	-142.667	-189.067	-205.979	-213.444	-221.506	-972.661

Fig. 5



Legend:

Costs/Benefits/Total

New transformer
Old transformer

Excerpt from Cost-Benefit-Analysis for Population Management (Rüdiger Faltin Hydro)

That it is unavoidable to reduce the need for replacements is evident not only from Fig. 2 but also from the overcrowding of manufacturers' plants – a sure indicator that the current situation may lead to uncontrollable conditions.

Luckily we now have ways and means for substance conservation which will lead to the desired results if used properly, as was presented in a very impressive manner. One of the industry's presentations made it very clear that a well thought-out course of action will ensure reliable operation of the equipment even if a population's substance is low. What makes this solution even more palatable is that it is also a commercial and economic success. It has been possible to demonstrate for some time that a relatively small assignment of resources will result in both operational safety and profits.

Summary:

Without a doubt the transformer issue is here to stay. And the need for action can no longer be dismissed. I will refrain from commenting on one of the most prevalent arguments claiming that transformers are uncritical assets due to their relative lack of failures during the past 30 years, due to the argument's innate lack of logic. Naturally, this same situation applies to all other components of the

power supply system. The issue of overaging of the entire plants and the need for reaction to this issue continues to be drowned out in today's discussions about liberalization, deregulation, and the other pet peeves of the day.

And yet, the time for orderly action continues to run out at ever increasing speed (see substance curve). Nobody can argue that the necessary solutions for successfully dealing with this solution are not already in existence. The opposite was proven clearly during all four of the events:

- The necessary data acquisition & measuring technology is available.
- Methods for turning data into action policies are being formulated by a number of international suppliers (example: EA-Technologies, DTC, etc.).
- Even conservation methods for turning action policies into specific clear-cut processes have been developed and are being used with great success.
- In addition to the technical necessity, even the bare monetary figures would suggest a planned course of action.

It is both possible and necessary to act now. While the industry has done its technical duty, the politicians remain a threatening presence lurking in the wings. But the idea that saving is tantamount to not spending any money has been clearly unmasked as an absurdity in the recent past. It is time to act for the commercial end of the users, in the best sense of the term 'businessman'!

QUESTIONS AND MORE INFORMATIONS

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