Condition based (Re-)Investment planning

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Education

M.Sc.Electrical Power Engineering-Karlsruhe-Germany

Professional Career

- DTC (Daemisch Transformer Consult) specialized in consulting for transformers and executing On-Line treatment of transformers and life time assessments – 2005 until now
- Owner and managing director of DIDEE GmbH (Daemisch Industriedienstleistungen GmbH) and – 1992 until now
- Independent – 1991
- Ginsbury Electronic – 1988
- Sales Engineer for southern Europe in MR (Maschinenfabrik Reinhausen) in Regensburg/Germany for OLTC's – 1985
- Sales Engineer for big power transformers in BBC Mannheim (ABB) for Latin America, Near East and other areas – 1978
- Sales Engineer for small and middle sized transformers in TRAFO UNION (Siemens/AEG) – 1975

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1. Introduction:

Even if the condition based maintenance is up to now not really introduced as the only acceptable option for the maintenance philosophy at power transformers we must now go the next step forward, using the knowledge of the condition of our assets to plan and co-ordinate the (re-) investment of one of our most important key asset:

The Transformer

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2. Introduction:

Very often, if we discuss with the users we find out that the classical preventive maintenance idea is already alive with the result, that due to

Unnecessary treatments finally unnecessary failures are produced.

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2. Introduction:

This is understandable, because in many cases the maintenance groups feel the pressure to do something in order to prove their necessity and to have in case of failure the answer, that there was done something and the failure cannot happened by lack of correct maintenance.

Nevertheless remains:

If the data do not indicate any corrective action:

DO NOTHING!

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3. Condition assessment:

Doubtless remains as the biggest challenge to understand the actual condition of a transformer.

There are offered nowadays a number of measurement systems and processes, which promise to give the user every all necessary data for evaluating the actual condition of his transformer.

Nevertheless data alone tell you :

Nothing

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3. Condition assessment:

1. The first step is to evaluate the data in a critical way in order to discriminate the reliable data from the wrong ones.
2. Based on the reliable data may be decided, if more measurements are necessary or not.
3. Having sufficient and reliable data a diagnosis can be elaborated.
4. Based on the diagnosis a action plan may be worked out, based on the complete technical and financial environment.

Health care planning

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4. Sampling and measurements:

Looking in some enquiries it seems, that the customers like to have the contractor coming with a complete truck of measurement systems, shutting the transformer down with the target to have now all possible information.

But makes this really sense?

Our experience tells a simpler story:

- Having a comprehensive DGA and oil quality history
- Making a well based reference sampling with reliable state of art equipment.

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4. Sampling and measurements:

The reference sampling should go together with a visual control of the transformers, also with a deeper discussion with the personnel in order to understand the individual condition in the plant and naturally the transformers there!

Based on such facts the first condition assessment can be finalized. Based on this further investigation may be made or in case the data are sufficient a final report can be delivered.

Needed is the expertise to transfer Data to diagnosis and from Diagnosis to adequate action

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5. Report and results:

The reference sampling should go together with a visual control of the transformers, also with a deeper discussion with the personnel in order to understand the individual condition in the plant and naturally the transformers there!

Based on such facts the first condition assessment can be finalized. Based on this further investigation may be made or in case the data are sufficient a final report can be delivered.

What must this report contain?

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5. Report and results:

1. **Actual health condition**
2. **Actual ageing condition (remaining substance)**
3. **Load capability assessment**
4. **Risk assessment**
- **Technical risk**
- **Financial risk**

5. Possible (necessary) actions

Based on the impact of item 4 determining the necessary actions in a

Health care plan

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6. The risk environment:

A Technical

- ageing condition
- failure mode
- load capability
- remaining life time under actual condition
- failure probability

B Financial

- financial consequences of a failure
- loss of asset
- loss of production
- collateral losses
- failure probability

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6. Technical versus Financial considerations:

A general problem in the whole story is that mostly there is not made a assessment of the technical risk in view of the financial considerations.

A highly endangered transformer in a certain application may remain acceptable and in service, since the consequences of a possible fault may be controllable and it would be economic to use the remaining substance to the highest extent.

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6. Technical versus Financial considerations:

On the other hand a much less critical transformer in a key application needs a complete different view, because its fault has tremendous financial implications.

Also using load tolerant transformers in high load condition areas, even with higher total losses is finally a more economic solution, as using less tolerant units with lower losses, because in the latter case the total life time costs are intolerantly high.

Result: It is a must to understand the technical and the financial background in order to optimize the

complete Population life cycle costs

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7. Specification:

The first condition, which must be considered, before the transformer is even ordered, is the correct specification. Today this paper must be much more stringent, than ever before, in order not to leave doors open for cheap and not adequate design and to get really comparable offers.

The required specification must cover:
- Correct temperature rise
- Correct temperature profile
- Adequate and technically sense making cooling systems
- Limits of Oxygen consumption
- Correct auxiliaries (for example sampling devices)

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8. Monitoring:

To understand and control the condition a more or less close monitoring must be implemented. What is close enough? The span reaches from regular (in a 3 – 24 month cycle) sampling and controlling to complex On-line monitoring up to On-line GC systems.

In which extent the monitoring should be done depends on the individual case. Nevertheless the data stream of monitoring systems must be canalized in order to have a use of it. Otherwise the data and therefore the monitoring is wasted money

Monitoring solves no problem and is not maintenance

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9. Treatments:

Based on the monitoring data certain actions should be implemented. To keep the transformer working certain maintenance procedures are on the market:

- Oil purification (treatment)
- Regeneration
- On-line conditioning

Oil purification does not fix real problems, like excess of water or gas. It is a simple cosmetical measure
Regeneration (reclamation) addresses oil ageing problems and is not a “wonder medicine” and is applied typically once in a transformer life
On-Line conditioning is the process to maintain the substance

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10. Examples:

The following examples show certain typical cases for investment or not investment, depending of the complete technical/financial environment.

- In the industrial plant a break down of 1 unit is tolerable, because of sufficient redundancy and spare available.
- Similar in the power plant for the start up transformer, but NOT for the substation auxiliary supply.
- Using the load tolerant older transformers with higher losses in the high load centers and the less tolerant low loss transformers in the low load condition means save life cycle optimization.
- In power plants is the "shut down" time the crucial point

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Examples:

Example 1 Aluminium smelter plant in Germany

Background:

- The plant is now over 40 years old and under the condition of the high energy costs the decision to keep it running or to stop is always a short term issue.
- The plant delivers high quality products, which will be preferably used in the neighbouring rolling plant.
- The whole plant is highly aged including the transformer population, which was also badly maintained till about the 90th of the last century.
- On the other hand to much investment under the above mentioned conditions was not acceptable.

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Examples:

Example 1 Aluminium smelter plant in Germany

Solution:

- Starting a correct monitoring program with regular oil and DGA tests.
- Based on this developing of a health care planning for the population.
- Investment in the necessary equipment for improving and preservation of the transformers.
- After achieving correct technical conditions of the transformer population by using the adequate technologies i.e. On-Line conditioners, reclamation etc. developing of a long term re-investment plan for that population.

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Examples:

Example 1 Aluminium smelter plant in Germany

Long term re-investment:

The population consists of three generations:

- The first installation about 40 years
- The second stage about 30 years
- The first reinvested units installed at 2000

The intensive condition assessment shows, that all three generations converge with their EOL prevision to about the same time in the next 5-10 years. (including the "new" generation)

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Examples:

Example 1 Aluminium smelter plant in Germany

In 2008 two new units a 35 MVA and a 20 MVA were delivered and two of the old units were sent to the factory for refurbishment.

At least the 35 MVA type has proven a very stable and long term tolerant design. For this reason a refurbishment seemed justified, even if the cost would be not much less or even equal to a new unit.

The assessment of the dismantled unit proved this point of view.

In the case of the 20 MVA unit the condition of the core sheets was so bad, that a refurbishment for this type made not really sense.

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Examples:

Example 1 Aluminium smelter plant in Germany

Long term aspect and planning:

In order to minimize the re-investment without reducing the reliability of the production the following policy was determined:

Since there is a 3 of 4 unit arrangement it is tolerable that 1 unit of the 4 units fails as far a replacement is available. The already working preservation programs are continued

So for every transformer type a spare is available, that a fast replacement of a failed unit is possible. So it is possible to use all units in their full life time cycle till the final EOL condition.

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Examples:

Example 2 Combined heat and power plant

Background:

A 2x 120 MVA CHP power plant 50 years old was planned to be shut down in the year 2012. So at a first step in 2006 the transformer population GSU, and auxiliary transformers were assessed and a health care planning defined in order to reach the planned shut down in a reliable way. Necessary treatments, like reclamation and using On-Line conditioners and On-Line monitoring were implemented.

2008 was decided to extend the life time of the plant to the year 2020. To cope with this situation a new planning was necessary.

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Examples:

Example 2 Combined heat and power plant

The new extended life time cycle needed a new assessment of the main transformers GSU, station auxiliaries and start up transformers. It now could not fully be assured, that all transformers could really reach the new target.

The possible options were assessed and evaluated:
Option 1 purchase completely new transformers
Option 2 try to survive with the existing transformers
Option 3 purchase only two new transformers (1 station auxiliary, 1 Start up). There was also a used GSU transformer, which could be adopted for that plant in good condition.

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Examples:

Example 2 Combined heat and power plant

Solution:
The option 3 was selected for the following reasons:
Purchasing new transformers was not only from the cost side not acceptable, also the risk of new transformers was not really improving the reliability.
To survive with the existing ones Option 2 was also not a acceptable reliable version.

Option 3 finally fulfilled all necessary requirements of reliable service on the one hand and minimized costs and risk at highest score of reliability.

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Examples:

Example 3 Transformer population of a rural utility

Background:

This utility positioned in a rural area has a transformer population with transformers up to 35 years. In order to understand the condition and be able to plan on middle and long term, there was awarded a first contract to DTC for the 20 oldest units up to 35 years age.

Later on for 20 units 15-30 years old.

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Examples:

Example 3 Transformer population of a rural utility 110/20kV 35/40 MVA

Result:

The first batch of older transformer had the surprising result, that these transformers were nearly in a "new condition" The reason for that is 1. the transformers are low loaded and the temperature exceeds seldom 50 C and 2. these transformers were of a good old highly tolerant design.

The second batch also showed, that the younger transformers of "modern" design were much weaker and presented under the same load and temperature condition indications of ageing.

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Examples:

Example 3 Transformer population of a rural utility 110/20kV 35/40 MVA
Final recommendations and new challenge:

In this case under the actual conditions no replacement or re-investment is necessary

A new challenge is now a load increase at certain places due to new renewable energy systems mainly wind parks.

Here was developed as new service a load capability study for transformers in order to select for these increased load the most tolerant units, since it was obvious, that different transformers of different design will not react in the same way on increased load. Another way to make best use of the investment assets.

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Case studies Health care planning

Example 4 Condition and Planning

The auxiliary transformers in a power plant must be assessed and a health care planning has to be proposed

PLant1	Condition	Measure	Priority	tecn. Risk	fin. Risk	Invest 2013 in T€	Invest 2014 in T€	Invest 2015 in T€	Invest 2016 in T€	Invest 2017 in T€
N 0BBT01	normal	O	5	6	2			20		
N 0BBT02	normal	O	5	6	2			20		
P 0BBT01	reduced	O;W	1	4	2	20				
P 0BBT02	Normal	O	5	6	2			20		
Y 3BCT70	Partially warm	O; W; R	1	2	5	32,5; 25			20	
Y 3BCT80	Partially warm reduced	O; W; R	1	2	5	32,5; 25			20	
Invest/ Jahr						135		60	40	

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Example 5

Recommended measure and risk

Scenario 1

Action : **NONE**

Result and Risk: GT2 and GT3 fast declining, GT3 and GT4 could result in breakdwon

Cost 0 , **Risk very high**

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Example 5

Recommended measure and risk

Scenario 2

Action : Reclamation and Re-inhibiting at GT2 and GT3, also
re-positioning of Hydran M2
Result and Risk: limited collateral damaged

Costs low (< 200k €), Risk remains high,

better controllable

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Example 5

Recommended measure and risk

Scenario 3

Action: Reclamation and Re-inhibiting at GT2 and GT3, also
re-positioning of Hydran M2, work with online monitoring
device, and prepare a spare transformer
Result and Risk: minimized

Costs high (~6 Million €) , Risk minimized

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10. Examples:

The examples show very clear the difference between technical and financial risk. Since the substation supply is integrated in the generator bus bar a failure means a shut down of the plant of at least 1 week.
For the start up transformers with the higher technical risk the financial risk and therefore the priority is much lower, because in case of failure alternative power sources are available without shut down.
Last example shows the result of a TPM (Transformer Population Management) study for a power plant in Indonesia. The purchase of a spare transformer remains the most favorable solution!

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11. Summary:

Saving money means to spend it in a intelligent and fact based way.

Means:

Gaining the data in a reliable way, using these data to transfer them to facts (Expertise!) and finally

Decision, well based on true facts implementing the necessary processes, investing the necessary money for the

most technical reliable and economically optimized solution

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