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TRANSFORMER SERVICES

Transformer Condition Assessment Strategy

(with Health Indices/Risk Indices for Transformer Fleet Management)

Question: *When is this transformer going to fail?*
Answer: This is a fair question to asked from any asset owner's perspective but a somewhat unfair question from a transformer specialist's point of view. What we know with great certainty is that the probability that a transformer will fail is 100%. The *when* is debatable due to the uncontrollable variables that the transformer is exposed to during manufacturing, in service network conditions etc. The exact date at which the transformer will fail cannot be determined with a high level of confidence

Question: *So, what can be used for operational and financial decision making for my transformer fleet?*
Answer: Knowing the above answer the focus needs to shift to determining the condition of each transformer, employing methods for early detection of faults, prioritising transformers with poor condition and applying suitable interventions. With this process the operational and financial decision making becomes condition based and data driven.

Congru Solutions offers customers a bespoke condition assessment strategy that will give credibility to operational and financial decisions. Our strategy has a proven track record with many of the major utilities, mining houses, heavy industry etc within Africa. Our staff has over 20 years individual experience and have established a database of thousands of transformers within the African continent. This has proven to be effective tool in understanding transformer failure modes within our local conditions and providing the optimum solution to customers.
Congru Solutions condition assessment strategies is broadly based on three approaches namely Fleet Appraisal, Fleet Survey, and Fleet Scrutiny.

Fleet Appraisal is the technical assessment performed by a Congru transformer specialist on readily available information. The transformer specialist performs *diagnostic, predictive and prescriptive* analytics on the data. The fleet is also compared to our database of transformer to identify weaknesses from sister units. The transformers are then ranked and assigned a risk index based on their condition indicators which are dielectric, thermal and mechanical *(if test results are available)* condition. This risk index/score is not a quantified probability but can be sufficient to identify assets that should be prioritised for intervention. The risk index/score is linked to a calibrated system categorising failure mode which is known as the scoring array. The following is advantageous to perform Fleet Appraisal and are given in the table below.

Historic Test Data	*Historic Life Information*	*Historical Documentation*
• DGA • Oil Quality • Furans • IR and PD scans • Electrical test • Factory Test report • Lightning data	• Nameplate information • Location • Loading records • Fault records • Protection scheme • Rewind and/or repairs • Tapchanger modifications/repair • Maintenance records	• Technical purchasing specification • OEM transformer file • Design report/notes • Strategic Spare • Database of transformers and location • Environmental concerns

Most fleet appraisal are performed with only current and accurate DGA data which is sufficient to score the transformer based on it dielectric and thermal condition. Other information is advantageous but not essential. Diagnostics are performed on the available information and the transformers are also benched marked against sister units in our database. Once completed each transformer is given a score based on its dielectric, thermal and mechanical *(if test results are available)* condition. Interventions and practically proven actions are specified if needed. For visualisation each transformer is designated a colour to classify its condition that is linked to the scoring array.

Substation	Circuit	Serial Number	Manufacturer	Year	Voltage Ratio	Rating (MVA)	Condition	Action	Overall	Dielectric	Thermal	Mechanical	Comments
Morningside	T1	287	A	1987	132/11	30	Healthy	None	3	1	1	1	
Windemere	T2	726	A	1987	400/275/22	500	Healthy	None	3	1	1	1	
Pinetown	T1	870	B	1981	132/11	40	Impaired	Drying techniques and repair of oil leaks	42	40	1	1	High moisture (35ppm) due to oil leaks
Bluff	T2	115	E	1972	275/132/11	315	Healthy	None	3	1	1	1	
City	T1A	210	A	1967	33/11	15	Unfit	Oil regeneration and electrical testing	102	100	1	1	High acidity (0.12). Requires PD scan
Overport	T1B	266	A	1974	132/11	40	Suspect	Perform SFRA after short circuit event	7	1	1	5	Know to be prone to hoop buckling
Chatsworth	T2A	629	A	1974	132/11	30	Healthy	None	3	1	1	1	
Umlazi	T2B	210	A	1967	132/11	30	Neglected	Oil analysis required (DGA and quality)	21	10	10	1	DGA not current last taken 18 months ago
Cleremount	T1	699	P	1980	33/11	25	Unfit	Electrical testing	200	100	100	1	Thermal fault involving paper insulation
Klaarwater	T2	809	D	1981	400/275/22	500	Healthy	Repeat DGA measurements	3	1	1	1	Abnormal Methane values
Hillcrest	T1	748	B	1977	275/132/11	315	Impaired	Perform DGA every 3months	52	1	50	1	Developing bare metal thermal fault

The key outcome for the Fleet Appraisal is the prioritisation of transformers that require immediate intervention and others that require short, medium and long term intervention. Which immediately helps with operational and financial decision making that are data driven.

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Fleet Survey is all activities within Fleet Appraisal but accompanied by online surveys. No outage is required to perform these surveys. Congru's highly experience staff will perform the following onsite assessments as per the table below:

Capture Nameplate detail	Visual inspection	Sound
Oil sample tested for: • *DGA* • *Moisture* • *Dielectric Strength* • *Acidity* • *Furans*	Partial Discharge (PD) scan • *Main tank* • *Tapchanger compartment* • *Cable compartment* • *Surge Arresters*	IR scan • *Main tank* • *Bushings* • *Connections* • *Radiators & Fans* • *Marshalling kiosk* • *Surge Arresters*

Congru's transformer specialist performs diagnostic, predictive and prescriptive analytics on the data and assigns a risk index to each transformer based on it dielectric, thermal and mechanical (if test results are available) condition. The Fleet Survey includes the advance testing of online PD scanning to improve fault detection. The additional online tests increase the confidence level of the risk index/score which now includes the surge arresters. This process is essential to prioritize transformers that will undergo a more detailed assessment during the Fleet Scrutiny stage.

Fleet Scrutiny is typically performed on transformers that have been assigned a high risk index from Fleet Appraisal or Fleet Survey. Further investigation would require an outage to perform the following offline electrical tests:

- *Power factor on windings*
- *Power factor on bushings*
- *Voltage ratio*
- *Exciting current*
- *Leakage reactance*
- *Winding resistance*
- *Insulation resistance*
- *SFRA*

These electrical tests are used to determine the severity and location of the fault. Congru's transformer specialist perform a detailed and thorough analysis of each transformer and then assign a risk index and in so doing creates a ranking based on condition indicators. Transformers are ranked based on most recent oil analysis, online scans and electrical tests into the dielectric, thermal and mechanical condition. There is no need to test transformers that have been assigned a low risk index from the Fleet Appraisal or Fleet Survey.

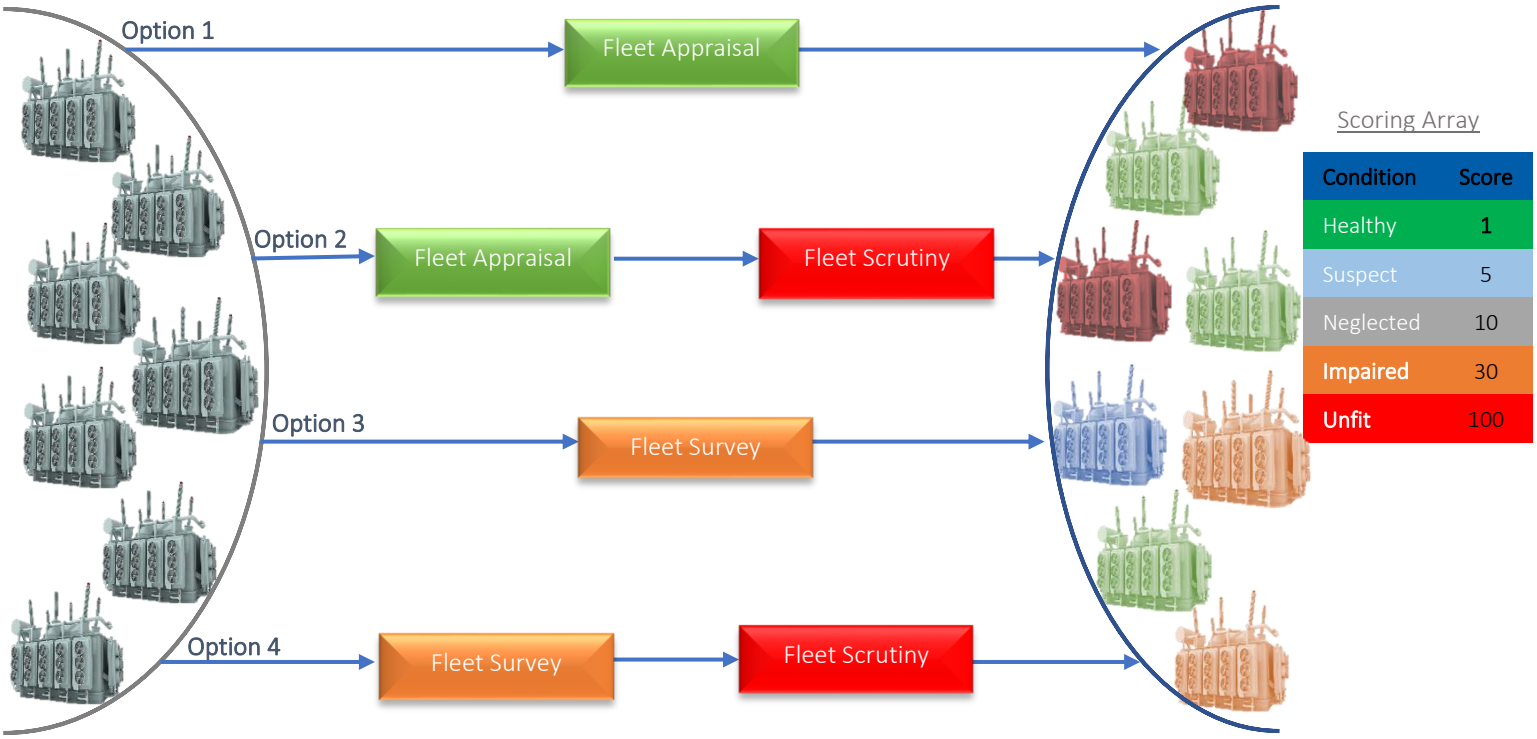
Summary

Congru's transformer condition assessment strategy can be customised to the customers budget and available data. Our approach has been to help the asset owner with operational and financial decision making that is data driven.

Assessment	Onsite work	Cost	Outage	Minimum Data	Risk Index	Ranking based on
Fleet Appraisal	*No*	*Low*	*No*	*DGA*	*Yes*	*Dielectric, Thermal & Mechanical***
Fleet Survey	*Yes*	*Moderate*	*No*	*None*	*Yes*	*Dielectric, Thermal & Mechanical***
Fleet Scrutiny	*Yes*	*Moderate/High**	*Yes*	*None*	*Yes*	*Dielectric, Thermal & Mechanical*

*Cost dependent on number of units require of offline testing. Not all transformers require testing ** Mechanical condition only if test results are available

Below are four (4) options that has been frequently chosen by our customers. We do not recommend doing Fleet Scrutiny on your entire fleet as performing offline tests on transformers with no indication of a concern is fruitless and costly.



Scoring Array

Condition	Score
Healthy	1
Suspect	5
Neglected	10
Impaired	30
Unfit	100

If you are interested and require more details, contact our transformer specialists:

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