Supplier Qualification – Factory Audits

Rafal Zaleski
Doble Engineering

Transformer Procurement Process

Theme for this presentation is: Who do I buy one of these from?

Transformer Procurement Process

So this this does not happen …

Transformer Works Test

Outline for this presentation:

Part 1

- Applicable standards and guides
- Quality Management System
- Environmental Aspects
- HS&E
- Human Resources

Part 2

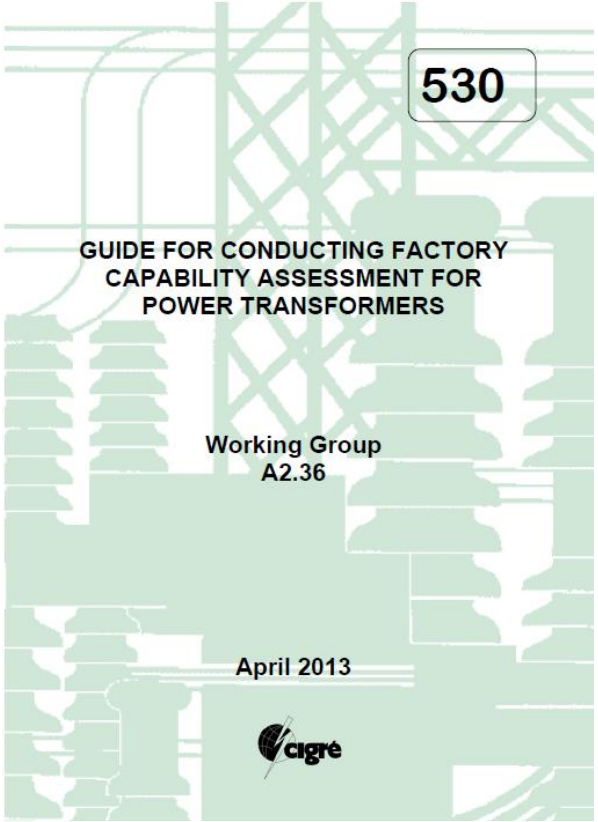
- Basic Technology
- Design Capabilities
- Supply Chain Management
- Production
- Test Laboratory

Part 1

Transformer Procurement Process

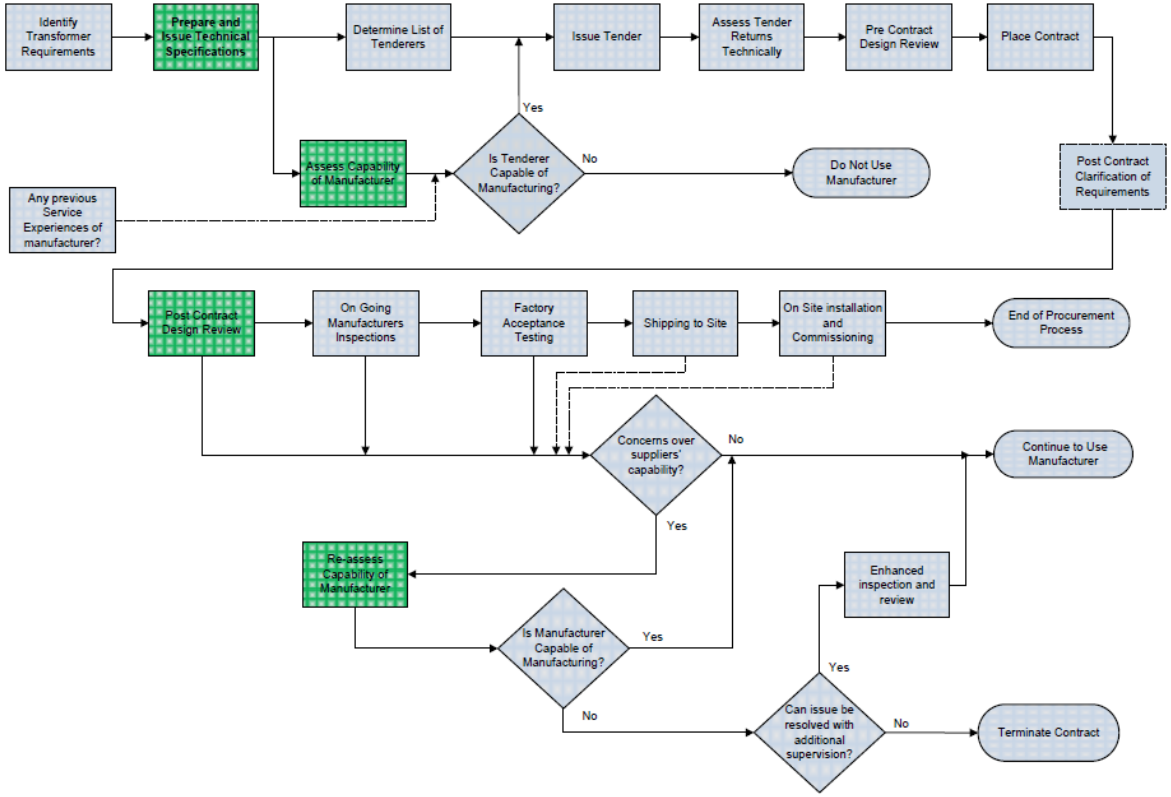
Applicable standards and guides

CIGRE brochure 530 on supplier qualification and development (“manufacturer capability assessment”) was first published in 2013. Two companion brochures published at the same time cover other aspects of the procurement process (brochures 528 on Specifications and 529 on Design Review).



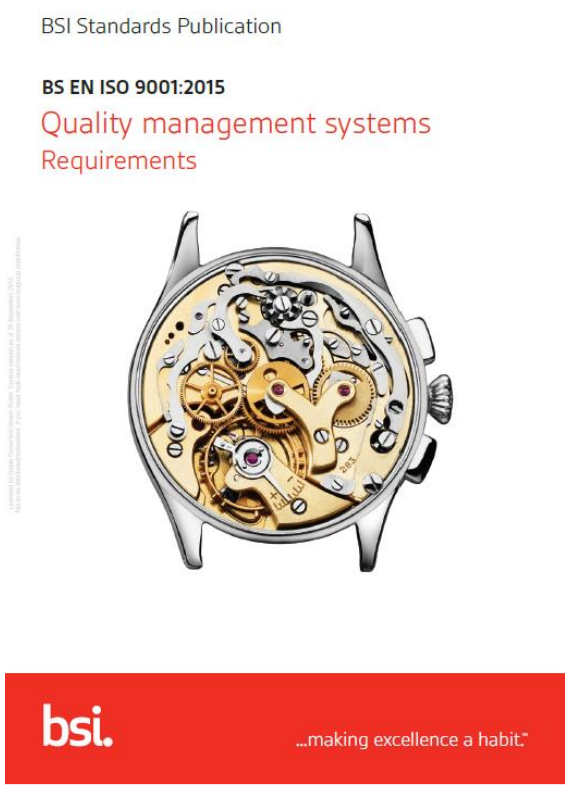
Transformer Procurement Process

One view (from CIGRE brochures 528-529-530)



Transformer Procurement Process

ISO standard 9001 gives requirements for quality management systems, which would seem to be a good start in supplier qualification and development.



Supplier Qualification

Aims of visit to supplier:

- Confirm accuracy of statements made by supplier during pre-qualification
- Ensure supplier has adequate engineering and management systems to understand and comply with user's expectation and requirements
- Ensure manufacturing and test facilities are adequate for production of transformers according to user's expectation and requirements

Supplier Qualification

Quality Management System

CIGRE brochure 530 begins with quality management, so this also seems to be a good place for auditor to start.

Almost every transformer manufacturer in World has a quality management system which is certified as being in accordance with ISO 9001 by an external partner.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Certification

SAMI TRAFO IND. TRADE CO. LTD.
H.Sabanci OSB. Anafartalar str. No.11 01350 Adana, Turkey

Bureau Veritas Certification Holding SAS – UK Branch certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standard detailed below

ISO 9001:2015
Scope of certification

Design, production and sale of oil immersed and cast resin transformers up to 66kV. Repair services of electrical equipment up to 110kV. Trading with electrical materials.

Original cycle start date: **11 October 2004**

Recertification cycle start date: **10 August 2015**

Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on: **17 August 2019**

Certificate No. BG.120819Q/U Version: **1**, Revision Date: **2 August 2016**

Signed on behalf of BVCH SAS UK Branch

Certification body address: 5th Floor, 66 Prescot Street, London E1 8HG, United Kingdom
Local office: Address: 61A, Bulgaria Blvd., 1404 Sofia, Bulgaria

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Supplier Qualification

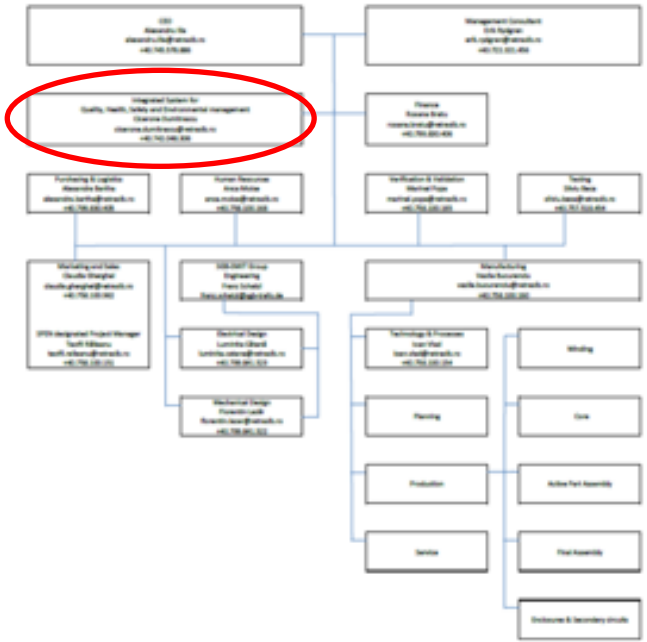
A good first question to ask about quality management, is about the management structure in general. Who does what? How does this support the quality management system?

Note: until the latest revision ISO 9001 required top management to identify a “management representative”, who was responsible for ensuring the implementation of the quality management system. In practice many companies have a quality manager or equivalent who is responsible for ensuring the implementation of the quality management system, with the support of other managers.

Supplier Qualification

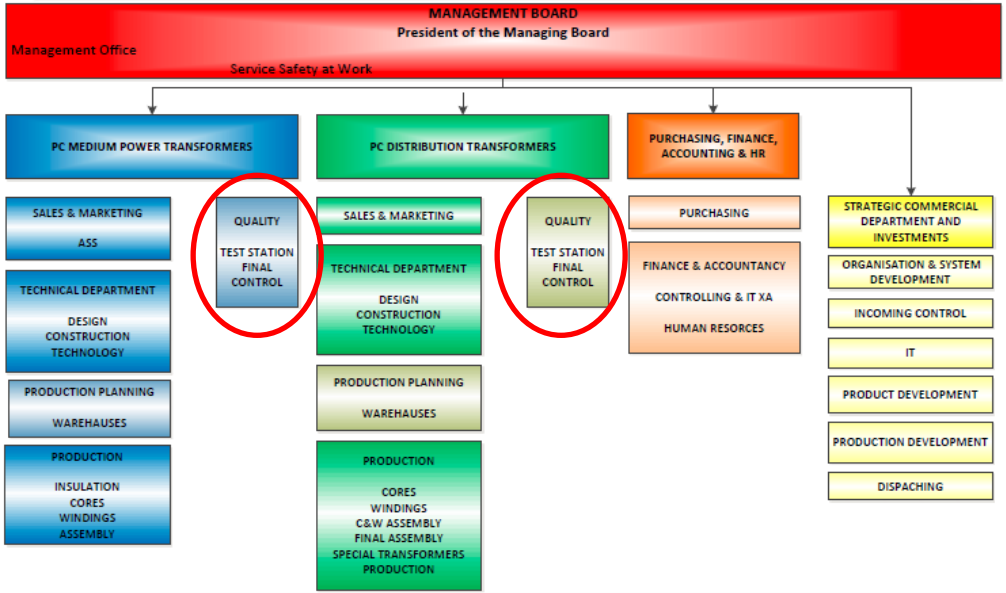
A typical organization chart for a transformer manufacturer.

There is a manager responsible for quality, environment, and health and safety management. His position is independent from other departments.



Supplier Qualification

Alternative, for a company with a divisional management structure. Each division has their own quality manager.



Supplier Qualification

An auditor will ask questions to recognize among others:

- How the quality management is organized
- How the Quality Department is structured
- How collaboration between departments in respect to quality is organized
- Whether there is a Quality Manual in place or how the quality procedures are described and distributed

Supplier Qualification

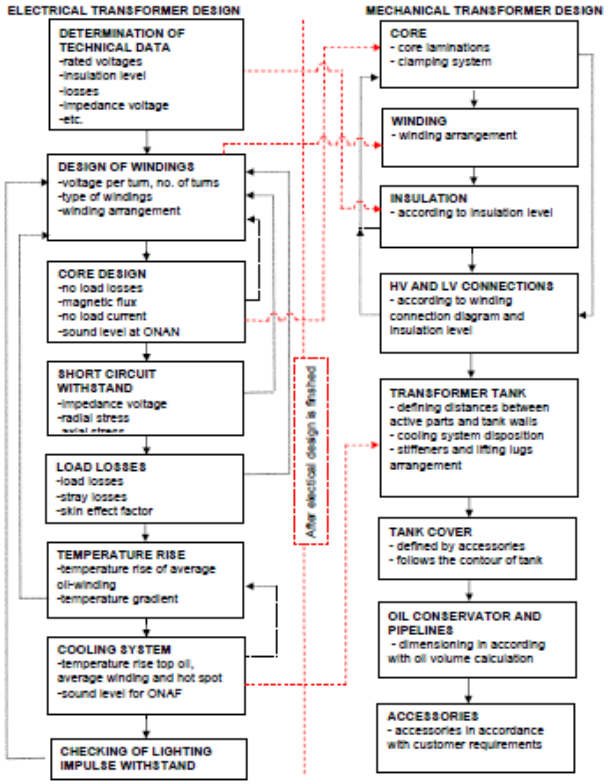
Once the Quality Management system is reviewed, an auditor will ask questions to understand more technical aspects:

- How are customer expectations recognized
- How is validation and verification performed
- How is customer involved in design approval

Supplier Qualification

One manufacturer's view of the design process.

In this case, mechanical design does not start until electrical design is finished. Customer design review is not shown, but would normally follow both electrical and mechanical design.



Supplier Qualification

Having prepared and documented a design, the next thing for the supplier to do is to source components and materials.

An auditor will be interested to review:

- Sample specification issued to the suppliers
- Sample incoming check procedure (inhouse, at supplier)

Supplier Qualification

Having sourced all components and materials, the next thing for the supplier to do is to manufacture the product.

An auditor will be interested to review:

- Quality management systems and procedures for checking work-in-progress: instructions, checklists, milestones…
- Methods of non-conformity reporting and follow up

Supplier Qualification

One more question for the quality manager (assuming there is one), is who is responsible for checking that the transformer meets all customer expectations and requirements, all tests have been passed successfully, all documentation is complete, etc. and the transformer can now be prepared for transport to the customer?

In other words: who gives final approval for the transformer to be transported to the customer?

Supplier Qualification

CIGRE brochure 530 recommends that manufacturers monitor the overall performance of their factory, and also the quality management system using the following three key performance indicators:

- Works test failure rate
- Service test failure rate
- On-time delivery rate

Especially for large power transformers, key performance indicators can vary considerably from year to the next and so it is best to look at them over a five year period.

Supplier Qualification

Environmental Aspects

ISO 14001 for environmental management system is closely analogous to ISO 9001 for quality management systems.

Not all transformer manufacturers have an environmental management system which has been certified as meeting its requirements, however all transformer manufacturers need to comply with environmental legislation in jurisdictions in which they operate.

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ISO 14001:2015
Scope of certification

Design, production and sale of oil immersed and cast resin transformers up to 66kV. Repair services of electrical equipment up to 110kV. Trading with electrical materials.

Original cycle start date: **30 October 2007**

Recertification cycle start date: **18 August 2016**

Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on: **17 August 2019**

Certificate No. BG.120819E/U Version: **1**, Revision Date: **2 August 2016**

Signed on behalf of BVCH SAS UK Branch

Certification body address: 5th Floor, 66 Prescot Street, London E1 8HG, United Kingdom
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Supplier Qualification

The role of environmental manager is often combined with that of quality manager (assuming there is one), or else delegated to a subordinate of the quality manager.

A few quick questions for the environmental manager:

- What are the main environmental hazards?
- How are the main environmental hazards controlled?
- How is waste managed?

Can the environmental management describe any recent improvements (i.e. in the last year) in environmental management?

Supplier Qualification

Heath and Safety

Some users are more concerned than others that their transformers are being produced in accordance with good practices.

ISO 45001, which has now replaced OHSAS 18001, for health and safety management systems is closely analogous to ISO 9001 for quality management systems. Not all transformer manufacturers have a health and safety management system which has been certified as meeting its requirements, however all transformer manufacturers need to comply with health and safety legislation in jurisdictions in which they operate.


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Certification

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STANDARD

ISO 45001:2018

SCOPE OF CERTIFICATION

DESIGN, PRODUCTION, SALE AND ERECTION OF PRESSURE VESSELS, HEAT EXCHANGERS AND STEEL CONSTRUCTIONS.

Certification cycle start date: 26 March, 2019

Subject to the continued satisfactory operation of the organization's Management System, this certificate is valid until: 3 April, 2020

Certificate Number: EST31517S Version: 2 Revision date: 26 March, 2019

Supplier Qualification

The role of health and safety manager is often combined with that of quality manager (assuming there is one), or else delegated to a subordinate of the quality manager.

A few quick questions for the health and safety manager:

- What are the main health and safety hazards?
- How are the main health and safety hazard controlled?
- How are employees engaged on health and safety matters?
- How accidents or other health and safety incidents investigated?
- How many accidents were reported to the lawful authorities?

Supplier Qualification

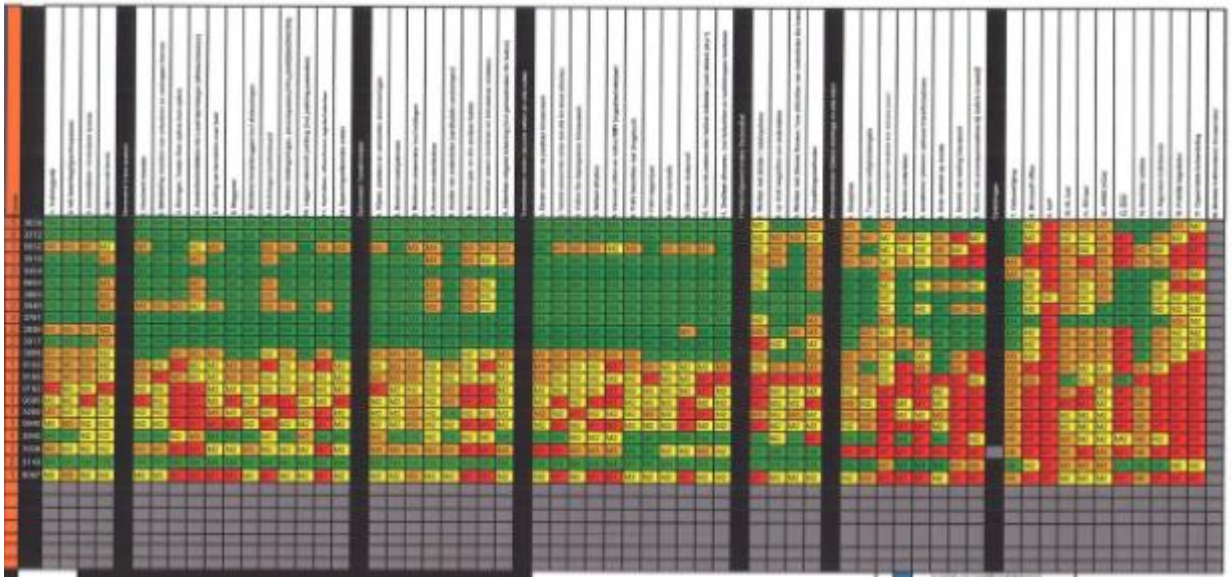
Human Resources

The first step an auditor will take is usually to identify the education and training requirements for each role at the supplier. Special attention needs to be paid to roles where it is challenging to recruit skilled workers, e.g. coil winders, electrical design engineers, mechanical design engineers, etc.

Supplier Qualification

The second step is usually then to map the skills of the existing employees onto the education and training requirements, to identify the need for further personal development.

Typical skills matrix



Supplier Qualification

A typical third step is then to identify the need for new employees – either additional (in case of expansion or a pre-existing shortage) or replacements (in case of retirement or changes in role). Many suppliers use the age and experience profiles of their existing employees as part of this process.

Age profile	15-25	26-35	36-45	46-55	56-65	>65
	5,3%	26,4%	28,5%	27,6%	11,9%	0,3%
Years of service	0-5	6-10	11-15	16-20	>20	
	47,6%	24%	3,3%	8,2%	17,8%	

Supplier Qualification

Two further points for ensuring that critical production areas are kept clean and tidy:

- Are there adequate sanitary and washing facilities available for all employees?
- Is there a canteen or mess room for all employees?
  Are any employees eating or drinking in critical areas?

End of part 1

Questions?

Part 2

Supplier Qualification

CIGRE brochure 530 suggests reviewing basic technology and design capabilities separately:

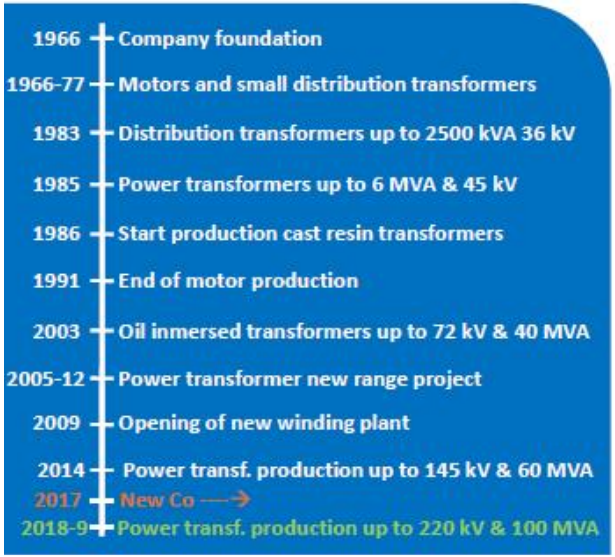
- Basic Technology, design concept.
  The manufacturer's standard design, especially for the core and winding assembly
- Design, design processes and systems
  How the manufacturer makes the electrical and mechanical design, including design verification and validation.

Supplier Qualification

Basic Technology

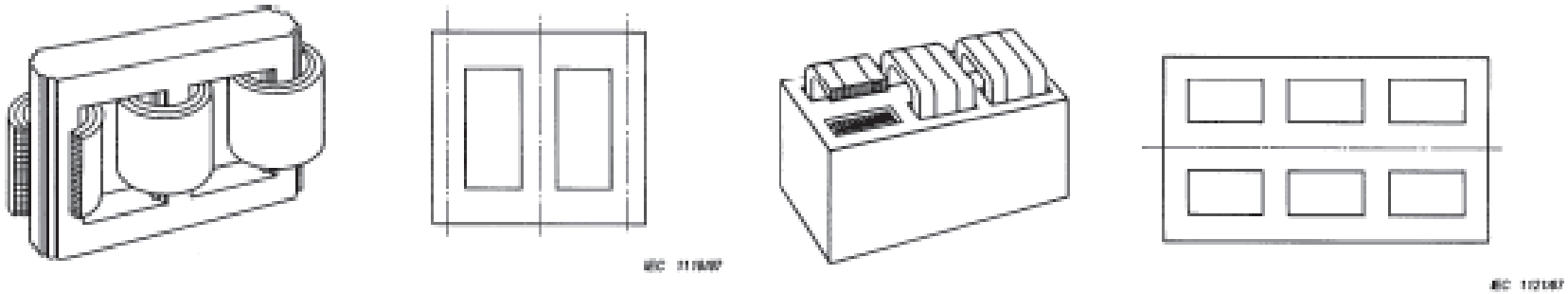
The auditor will ask a number of questions to understand how the basic technology was developed:

- History and milestones
- Technology partners for design concept



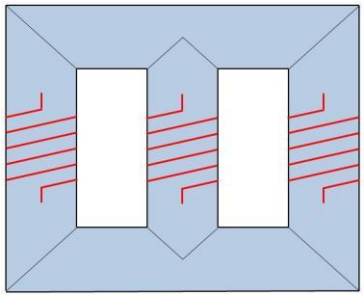
Supplier Qualification

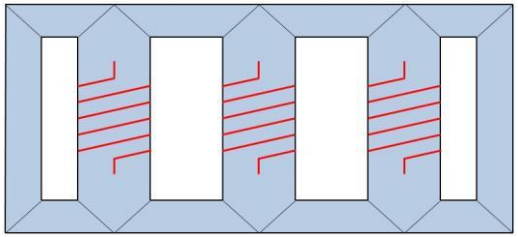
Does the supplier use core-form or shell-form construction? In case the supplier uses both, for what range of rated voltage and rated power? Are there any applications where one form of construction or the other is preferred?



Supplier Qualification

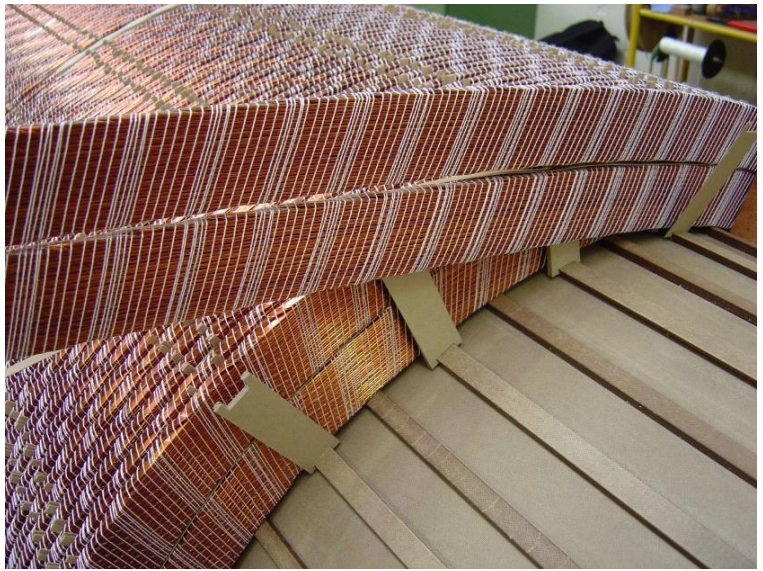
What types of core design does the supplier use for single-phase and three-phase transformers. If more than one type of core design is used, for what range of rated voltage and rated power? Are there any applications where one core design or another is preferred?





Supplier Qualification

What types of winding design does the supplier use for different rated voltages and rated currents? Are there any applications where one winding design or another is preferred?



Supplier Qualification

What types of tank design does the supplier use for different rated powers and rated voltages? Are there any applications where one tank design or another is preferred?

Supplier Qualification

What types of cooler design does the supplier use for different rated powers and rated voltages? Are there any applications where one cooler design or another is preferred?

Supplier Qualification

Short-circuit withstand tests are important in validating the supplier's design concept.

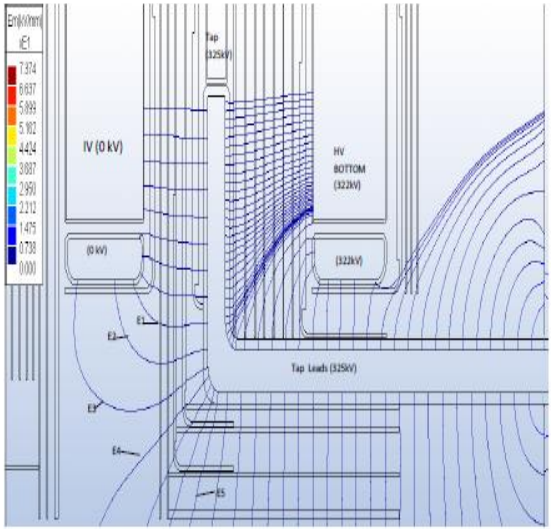
How many short-circuit withstand tests has the supplier made? When? Where, i.e. at which laboratory?

Supplier Qualification

Design Capabilities

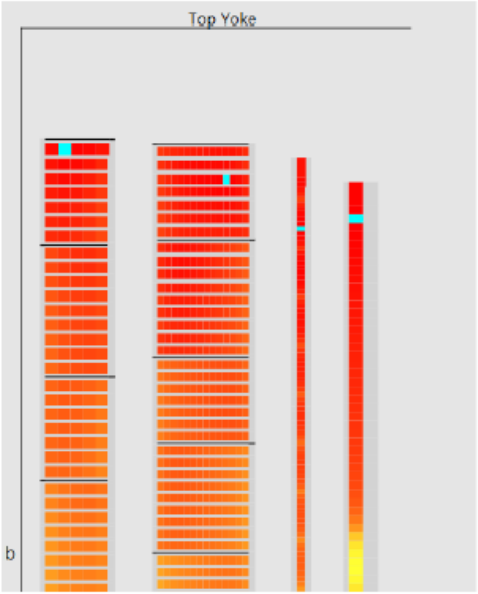
An auditor will make efforts to assess design capabilities of Engineering department. What advanced methods does the supplier use?

- Magnetic field
- Impedance, eddy current losses, stray load losses, short-circuit forces
- Electric field
- Main insulation design, lead design



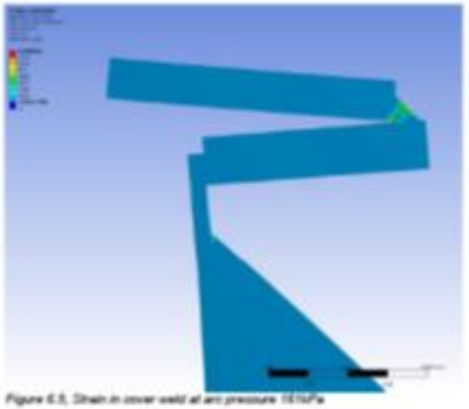
Supplier Qualification

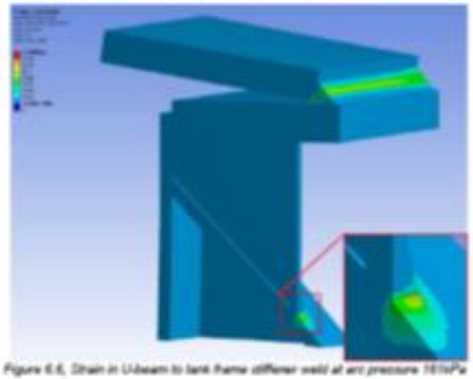
- Transient Voltages
- Winding insulation design, lead design, tapchanger selection
- Coolant flows and temperature distribution
- Winding thermal design (inc. hot-spot temperature calculation), cooler design



Supplier Qualification

- Mechanical strains and stresses
- Design of steel work (inc. vacuum and pressure withstand capability of tank, rupture strength of tank, design of lifting and jacking points)





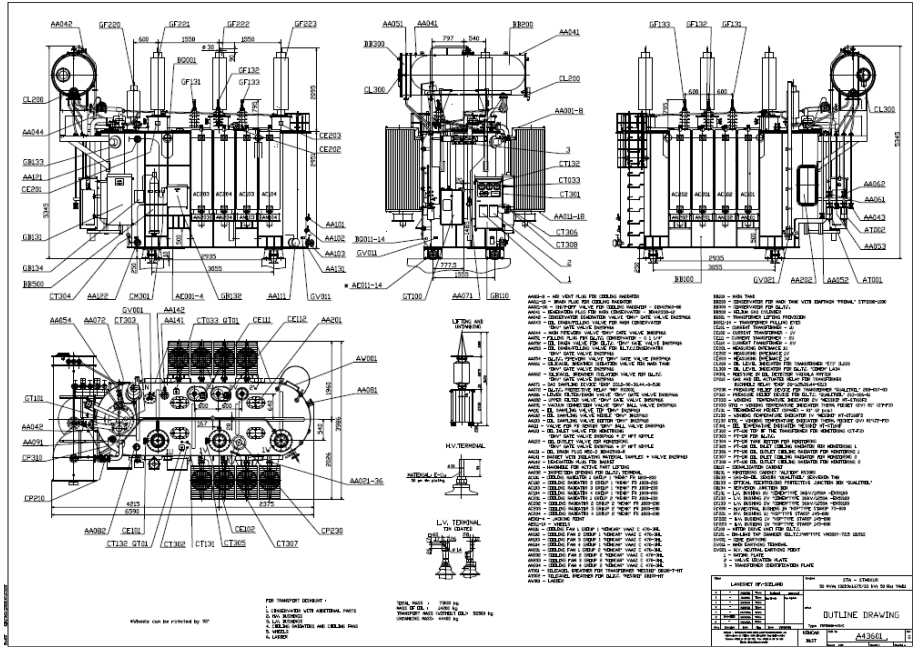
Supplier Qualification

Supply Chain Management

Consider a simple medium power transformer. How many components are needed to build it?

Supplier Qualification

The overall dimension drawing parts list includes approx. 100 components from more than 10 suppliers



Supplier Qualification

The overall dimension drawing represents the tip of the iceberg, and the transformer likely includes more than 10000 components from more than 100 suppliers

Supplier Qualification

An auditor will want to verify management procedures and systems for supplier qualification and development, to ensure that suppliers are capable of meeting customer expectations and requirements?

A related question, is what management procedures and systems are in place for checking components and materials need to be checked for conformance with specifications and other documentation, and by extension customer expectations and requirements?

Supplier Qualification

A quick reminder of some of the more important components and materials:

- Core laminations
- Winding conductor
- Solid insulation (board, laminated material, resin-glass, etc).
- Oil
- Steel fabrications
- Valves
- Gaskets and seals
- Coolers (radiators, fans, pumps, compact coolers)
- Bushings and terminals
- Tapchangers
- Sensors (CTs, OTI, WTI, fibre-optics, Buchholz relay, PRDs, etc).
- Control cabintes

Supplier Qualification

An auditor may ask the following questions about each important component or material:

- Who are the main suppliers?
- How were they selected?
- When did you last visit them?
- What is their performance, and how is it monitored?
- Are you satisfied with them?

Supplier Qualification

Factory Tour

An auditor will want to see the production floor, beginning with the storage area and then, following the flow of the materials around the works to the tanking/preparation for transport workshop.

In each workshop he will ask about:

- the equipment installed there and its capabilities.
- the quality documentation, to ensure that it has been completed correctly.
- calibrated work equipment to ensure that it is still in calibration.

Supplier Qualification

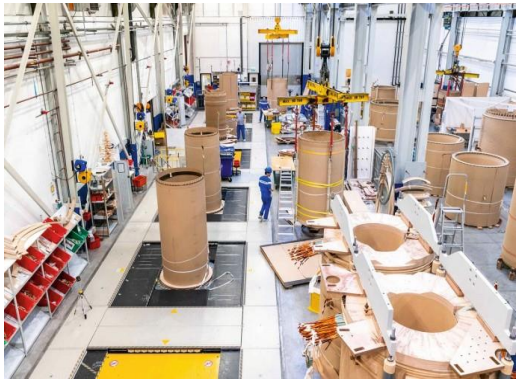
In each workshop, build quality of work-in-progress will be checked:

- Are there any gaps in stacked cores?
- Is winding end blocking correctly aligned? Is use of glue well-controlled?
- Sufficient care of paint finish during tank/preparation for test/preparation for transport?

Supplier Qualification

In each workshop, cleanliness/tidiness will be assessed:

- Are workshops which might generate contamination segregated from the rest of the works? If so, how?
- Are workshops which might be affected by contamination segregated from the rest of the works? If so, how?
- How often are floor areas cleaned? Is there any debris or duct visible on the floor? Is there any dust visible on horizontal surfaces?
- Are there any birds or other animals in production areas?



Supplier Qualification

An auditor can also ask questions about:

- production capacity of the works
- Type, procedure and capacity of drying process
- Procedure to limit moisture ingress after dryout
- Brand and type of oil used in a factory
- Capacity of cranes and hoover systems

Supplier Qualification

Test Laboratory

There are three main types of test laboratory:

- A test area in the main workshop
  Background levels of both sound and partial discharge are high. Testing may disrupt production, and production may disrupt testing.
- A separate test area
  No shielding against electromagnetic interference
  Background levels of sound are lower than for a test area in the main workshop. Testing will not disrupt production, but production may disrupt testing

Supplier Qualification

There are three main types of test laboratory:

- A full or partial Faraday cage
  With full or partial shielding against electromagnetic interference
  Background levels of sound and especially partial discharge are lower than for a test area in the main workshop. Testing will not disrupt production, and production will not disrupt testing
  Rise in ambient temperature can be an issue during temperature rise tests.

Supplier Qualification

Test Laboratory

The auditor will assess the laboratory in respect with:

- Type of separation from manufacturing floor
- Type and calibration of equipment
- Voltage, real and reactive power capacity of the supplies

Supplier Qualification

A quick reminder of some of the tests we need to perform:

- Winding resistance
- Transformation ratio
- Load loss and impedance
- No-load loss and current
- Zero-sequence impedance
- Tapchanger functional tests
- Pressure (leak and deflection)
- Vacuum (leak and deflection)
- Insulation resistance (windings and core/frame)
- Capacitance and power factor (windings and bushings)
- Temperature rise
- Lightning impulse
- Switching impulse
- Applied voltage
- Induced voltage
- Sound levels
- FRA

Supplier Qualification

This impulse measurement system had been out of calibration for nine weeks at the time of the inspection.

Supplier Qualification

The power analyser in the loss measurement system in this test laboratory had been out of calibration for six weeks at the time of inspection.

Note: this was ten years ago and the supplier are now under new management, and performing a lot better.

Supplier Qualification

Depending on a scope of order, auditor might be interested in any follow up activities once the transformer has been successfully tested:

- Packing and dispatching
- Transportation
- Installation and commissioning
- Warranty

Supplier Qualification

This is up to customer to decide after audit, which manufacturers will be awarded with an order. Below, several examples, where manufacturers were not qualified.

1. Manufacturer in Asia. Many Quality problems, lack of transparency.
2. Manufacturer in Europe. Test equipment not in calibration, quality problems.
3. Manufacturer in Europe. Not enough reactive power for required transformers.
4. Manufacturer in Asia. Lack of relevant experience, poor engineering, poor project management.
5. Manufacturer in Europe. Misleading statements made during early stage of tender.

End of part 2

Questions?

联系信息

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doble isa MS MORGAN SCHAFFER PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

宋 智　Hans Song

道波（Doble）、特因普（Techimp）、MS 中国销售经理

✉ HSong@doble.com

+86 187 2152 3072