GENERATOR REWIND SPECIFICATIONS – HOW MUCH DETAIL IS TOO MUCH?

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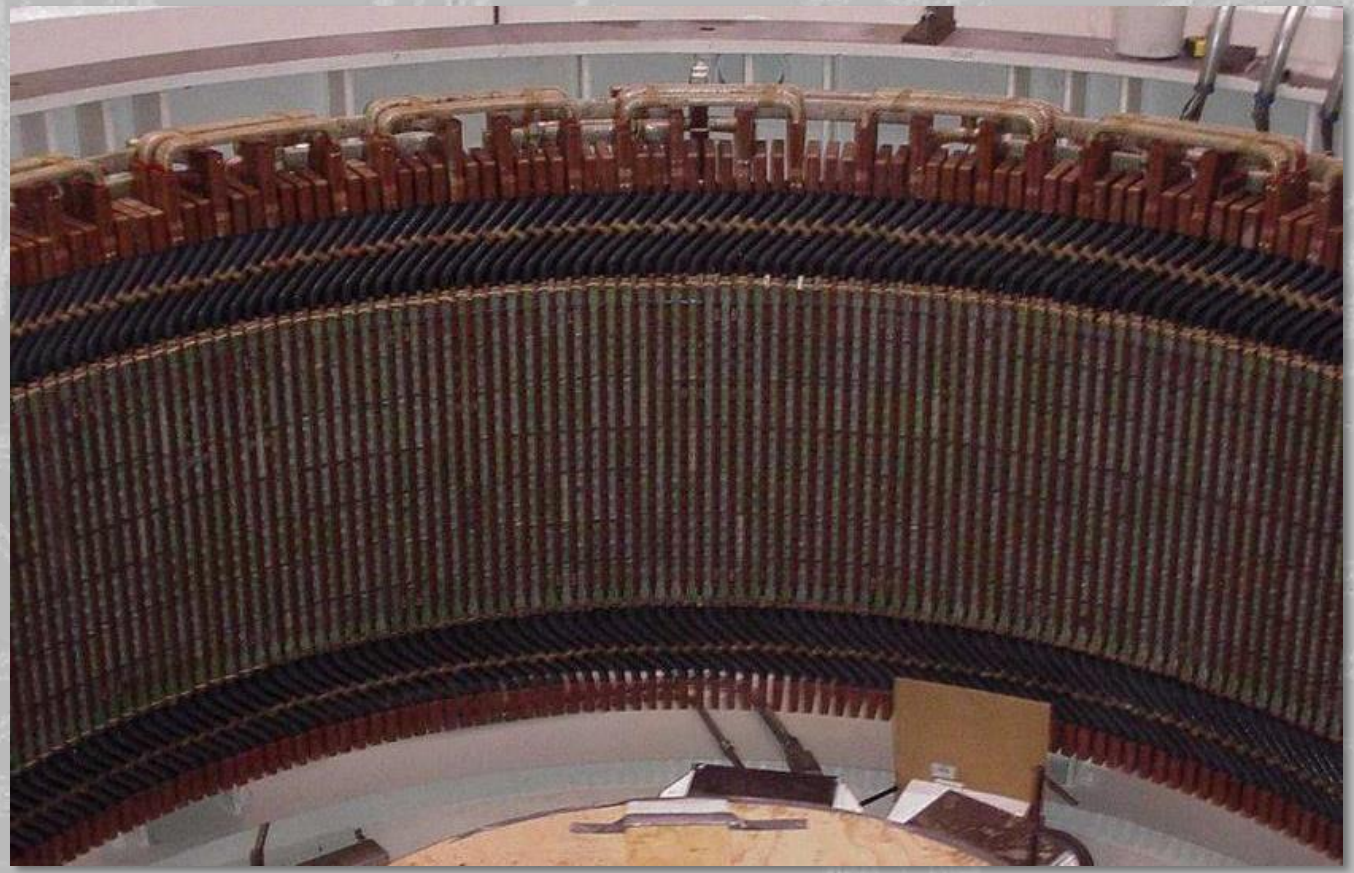

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DO YOU NEED DETAILED SPECIFICATIONS?

Not if there is a common understanding of expectations:

Example – specify a common object

– “regular” Pencil
  - Highly likely to get a round or hexagonal, 7 ½“ long, cedar encased, graphite lead pencil, #2 or HB hardness, with an eraser held attached to one end with a metal ferrule

– Mechanical pencil
  - Many more options available so less sure of what you’ll get – variables include lead size, hardness, lead storage capacity, lead advancement mechanism type, optional retractable lead guide, eraser size, color, shape, material, etc.

The more variations there are for an item among suppliers, the more detail you need in the specifications - IF you have a requirements for the end product.

STATOR REWIND SPECIFICATIONS

Purpose of Technical Specifications is to clearly state the requirements of the new stator winding and the scope of the work to rewind the generator.

– Long and reliable service life of winding is objective
– Include requirements and expectations for design and manufacturing of the winding
– Don't forget requirements and expectations for installation work too

If the Owner and potential Suppliers have identical understanding of what is required, expected, and will be supplied, the specifications can be less detailed.

If there is the possibility that the Owner and the potential Suppliers might have different understandings of what is required, expected, or will be supplied, the specifications must include more detailed requirements.

FACTORS TO CONSIDER

Objectives of rewind may affect the level of detail required:

– Rapid return to service of a failed unit, or time based replacement of a “disposable” component of the generator
– Restart the “life” on a generator to run another 40+ years
– Rewind as part of a major unit rehabilitation including turbine runner replacement
  • Rewind could be delegated to a subcontractor
– Significant rating or other design change is desired
– Operating mode of the generator has changed significantly
  • What worked for base load may not be ideal for cycling operation

Other factors that could affect the level of detail required:

– Are Suppliers pre-qualified such that the Owner knows what to expect?

HOW MUCH DETAIL TO INCLUDE?

Sufficient detail needed to provide assurance desired level of quality is met
vs.
Too much detail can result in limiting or conflicting design choices

Suppliers have internal design standards they will follow, but not all Supplier's processes are the same.

In general, the fewer the specification details, the less expensive the winding as the Supplier has more latitude in design and manufacturing.

Specify minimum Owner requirements, allow alternate proposals above minimum and evaluate accordingly

RELYING ON STANDARDS TO COVER DETAILS

Standards rarely address manufacturing, mainly performance and testing

Standards are not always “standard”
– IEEE/ANSI vs. IEC or others

Supplier with large customer base outside North America may have processes adjusted to IEC standards.

Standards are not always directive
– Guide (may or should), Recommended Practice (should), Standard (shall)

Even “standards” often include several options for performing tests, and may not have pass/fail criteria

Specifically cite what test method and criteria you require, even if it is not a “standard” requirement.

SERVICE AND SCOPE OR WORK DETAILS

Identify the conditions under which the rewound generator must be capable of operating
– Operating temperatures, loading rates, start per day (or week or month), etc.
– Consider stating how long the winding is expected to last
– Consider whether rewound unit should meet or exceed original unit temperature rise limits

Describe what work is and is not included in the rewind scope
– Design and manufacture the stator winding
– Removal of old stator winding?
– Cleaning and testing of stator core?
– Supply and install new core?
– Installing and testing the new winding?
– Cleaning and testing of field winding?

Determine what to do about asbestos and lead based paint before requesting rewind proposals!

If Supplier is installing the winding, on-site logistics details are needed too.

MACHINE DATA AND CONDITION DETAILS

Nameplate information

Physical attributes
– Stator details (bore diameter, height, number and size of ventilation ducts, end packet info, etc.)
– Number of slots, winding pitch, finished slot dimensions, straight or skewed slots
– Direction of rotation
– Existing winding details (coils or bars, turns per coil, circuits per phase, lap or wave winding, etc.)
– Existing degradation (core damage, bypassed coils, etc.)

Identify whether a pre-bid generator inspection opportunity is to be provided
– Machine state during inspection (partially disassembled, rotor out, etc.)
– Samples of coils/bars available?, spare laminations?

Provide temperature and losses data from the heat run tests for existing unit to allow ventilation and other factors that may not be changed by the rewind to be evaluated.

SUBMITTAL DETAILS

Determine what design information should be submitted for information or approval:

– Drawings
  - Winding diagram, slot cross section, coil or bar outline, winding installation details, circuit ring and surge ring details, etc.
  - Core laminations, keybars, frame modifications, lamination punching die (if new core is in scope)

– Procedures
  - Manufacturing (general), winding removal, core cleaning, winding installation, factory and field testing, etc.

– Calculations
  - I^2R and stray load losses, expected temperature rise, slot closing wedge forces

– Material descriptions
  - Strand conductor, insulation materials, lamination characteristics

– Inspection and Test Plan and Test Reports
  - Stator and rotor inspection reports, factory and field coil or bar, and completed winding test reports

– Owner hold points

Submittals take time and effort from Supplier to prepare and from the Owner to review – balance the need for the submittal with the value achieved by getting it.

INSULATION DESIGN DETAILS

Specify constraints for coil/bar conductor and insulation materials, but not detailed requirements

– Requirements for strand conductors - material, smoothness, hardness, splices allowed, etc.
– Strand or turn transposition required?

– Preference for strand insulation – type and, for coils, whether all strands need to be insulated similarly (brick type strands allowed?)
– Preference for dedicated turn insulation in coils
– Acceptable types of main insulation, maximum voltage stress levels (but not number of tape layers)

Slot and end arm corona suppression treatments – are they required, and if so, are either paints or tapes acceptable?

Minimum overlap between slot section corona protection and end arm grading treatment

WINDING DESIGN DETAILS

Should all coils and bars be interchangeable or can they be made for specific locations?

Finished coil/bar dimension tolerances, particularly the slot section

Acceptable characteristics of bottom, middle, top, side fillers, and wedging systems

Re-insulate or replace circuit rings and supports, pole group jumpers, main and neutral leads, support (surge) rings

Instrumentation requirements
- Number and type of slot RTDs
- Number and type of partial discharge sensors
- Number and type of other sensors
  - Air gap, flux density, pole face temperature, etc.
- Neutral current transformers

FACTORY TESTING DETAILS

Incoming raw materials
– Accept standard Supplier testing, or
– Specify additional testing

Testing and reporting requirements for testing during manufacturing process
– purpose is to catch problems as early in process as possible

Testing of completed coils or bars
– Routine testing that all coils and bars must pass
– Special testing that a few coils or bars must pass (may be destructive)
– Prototype testing that a few initial coils or bars must pass (may be destructive) to prove the design before production of actual winding starts

SHIPPING AND PACKING DETAILS

Expectation - that the coils or bars will arrive on-site suitable for use.

What steps are to be taken to ensure they remain dry and secure from shipping damage (movement in the crates and damage from reasonably expected outside forces)?

Supplier and Owner should agree on required winding storage conditions too.

Simple to put the responsibility on the Supplier, but problems will adversely impact Owner's outage schedule.

Example – Supplier followed good internal process and carefully packed and sealed coils in water tight envelope with desiccant. Crate builders punctured envelope by using improper length screws to secure lid. Result was wet coils on arrival at project.

INSTALLATION DETAILS

Who will disassemble and reassemble generator?

Who removes old winding from core and properly disposes of it?

How will the core be cleaned, tested, and repaired before installing the new winding?

How will the coils or bars be handled (moved into the generator to minimize handling damage?

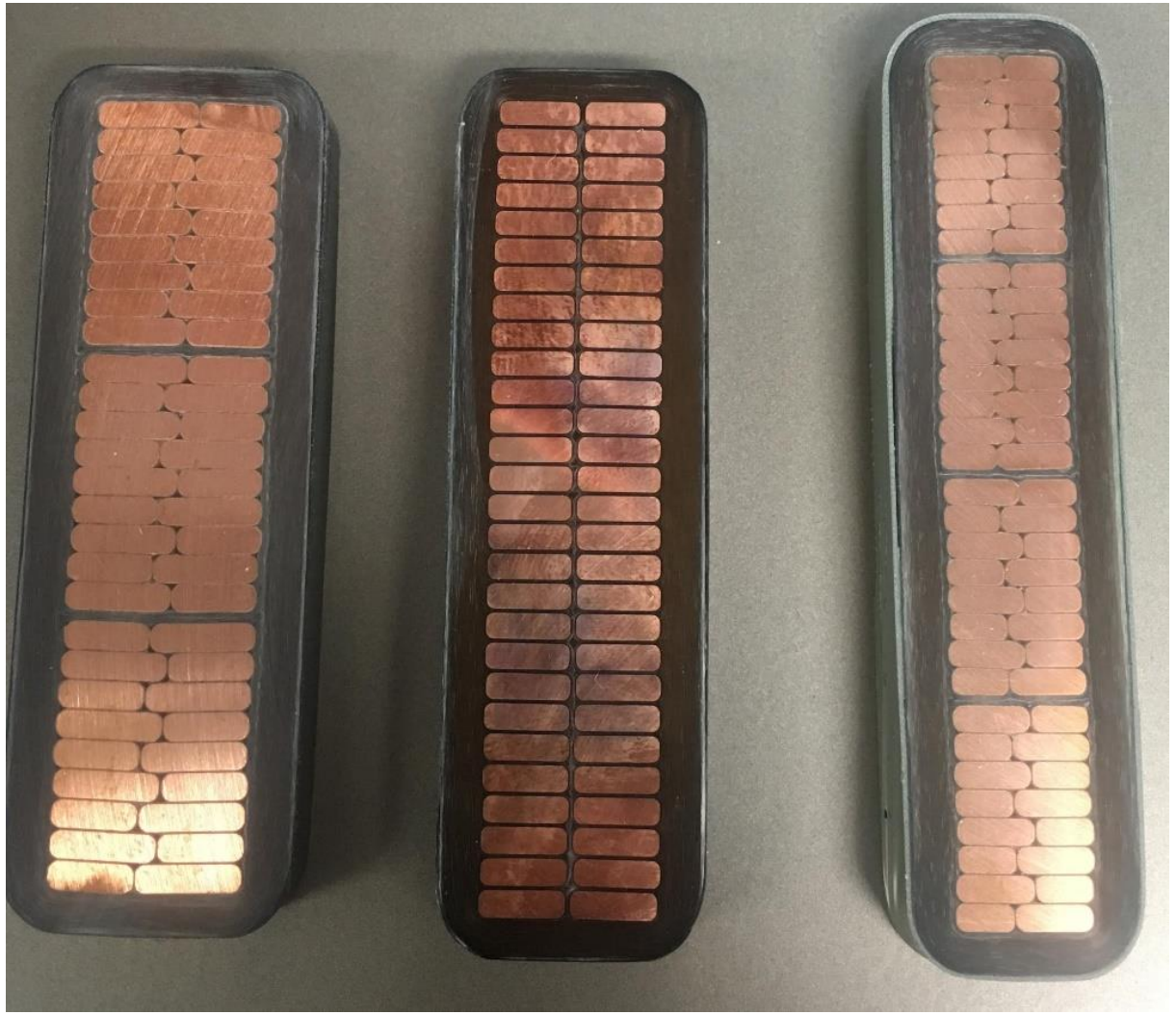
In-process testing
– Coil or bar resistance to ground
– Coil or bar hipot tests (after wedging before lashing)
– Turn test (before too many coils are covering tested coils)
– Transposition group (for externally transposed coils)

Final acceptance and other testing

POSSIBLE IMPACTS OF TOO MUCH DETAIL

Including specific requirements instead of performance can limit design choices:

– Dedicated turn insulation
  - Requiring dedicated turn insulation might be chosen to reduce the chances of turn shorts in the future
  - But uprate and operating temperature objectives may be unachievable with it due to copper cross section reduction.



POSSIBLE IMPACTS OF TOO MUCH DETAIL

Including specific requirements instead of performance can limit design choices:

– Too stringent test criteria can result in the Supplier designing the coil/bars to pass the test, not necessarily to maximize winding life
  - Voltage endurance and thermal cycling tests are claimed by some Suppliers to result in designing to pass the test at higher costs with undefined improvement on winding life.

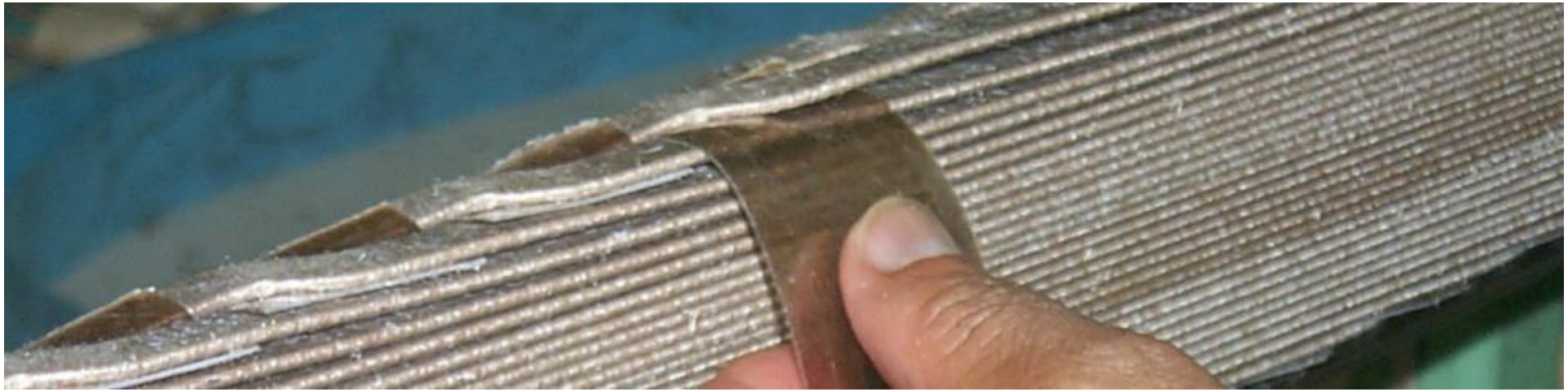
– Requirements that force the Supplier to deviate from internal processes may cost more, slow down manufacturing, or extend schedules.

POSSIBLE IMPACTS OF TOO MUCH DETAIL

Excessive testing or Owner “hold points” between manufacturing phases can both extend schedules and increase costs

– Hold between prototype coil test approval and production run coil manufacturing
– Required test at beginning and end of steel rolls for lamination punching

Use of Daglas© strand insulation for bar strands instead of enamel - requires additional steps to prevent strand shorts at the crossover, more manufacturing steps and labor



POSSIBLE IMPACTS OF TOO LITTLE DETAIL

Owner expressed performance requirements, but left all details to Supplier. Sometimes that works out fine, others times it doesn’t.

– Poor corona control systems as performance requirements for no visible corona or required overlap between slot and grading treatments not specified
– Excessive insulation electric stress (v/mil) as upper limit was omitted and Supplier maximized ampacity over dielectric stress levels
– End wedges secured with epoxy resin, but so much resin was used wedges couldn't be removed later without damaging coils or wedge grooves.

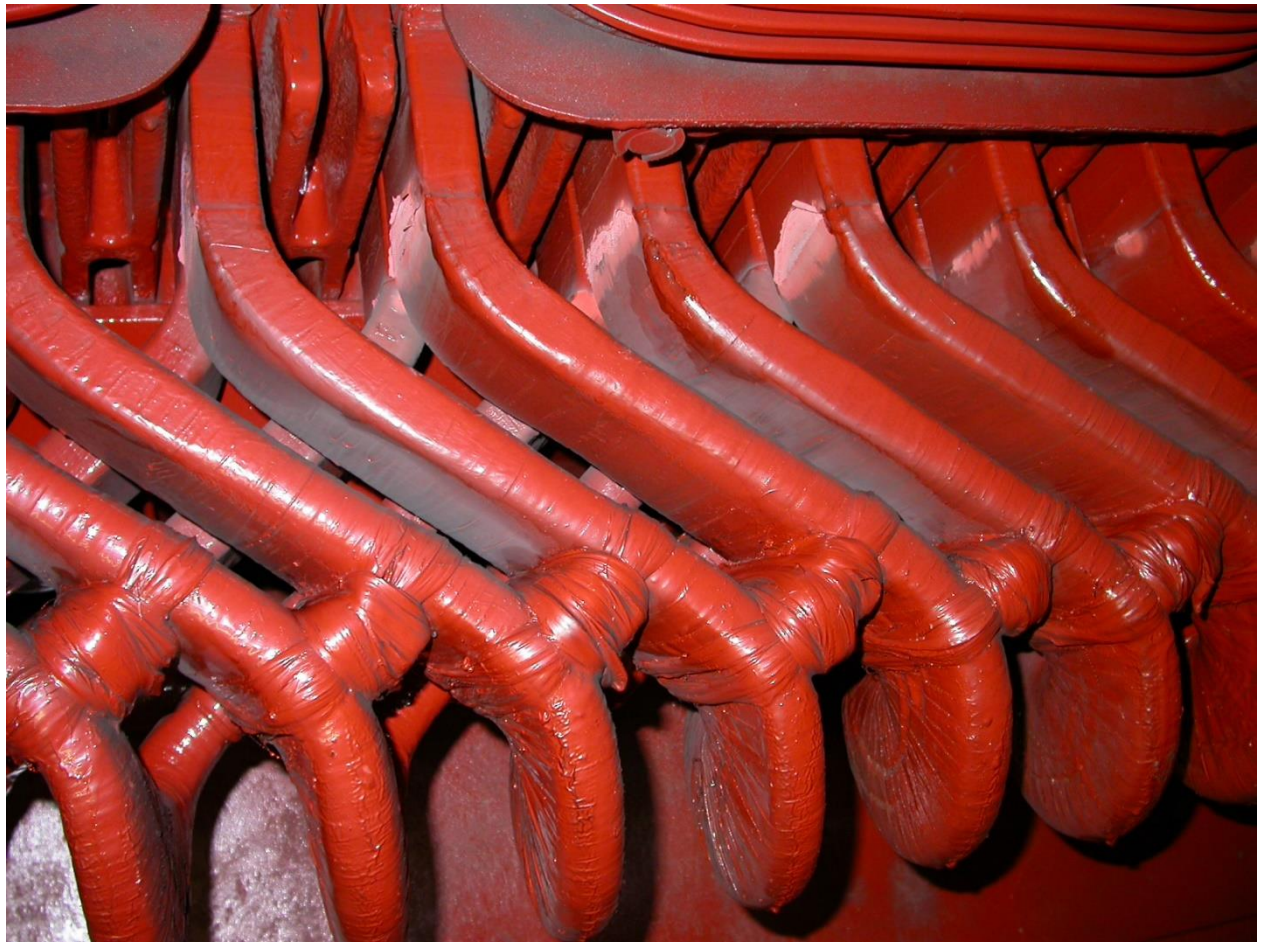
– Problems may not occur in the warranty window.

– Additional costs to get the features, information, or capability that the owner expected from the rewind, if the problems can even be solved after the installation is complete.

SPECIFICATION DETAILS EVOLUTION

Detailed requirements tend to get added to specifications to prevent an unexpected problem from happening again.

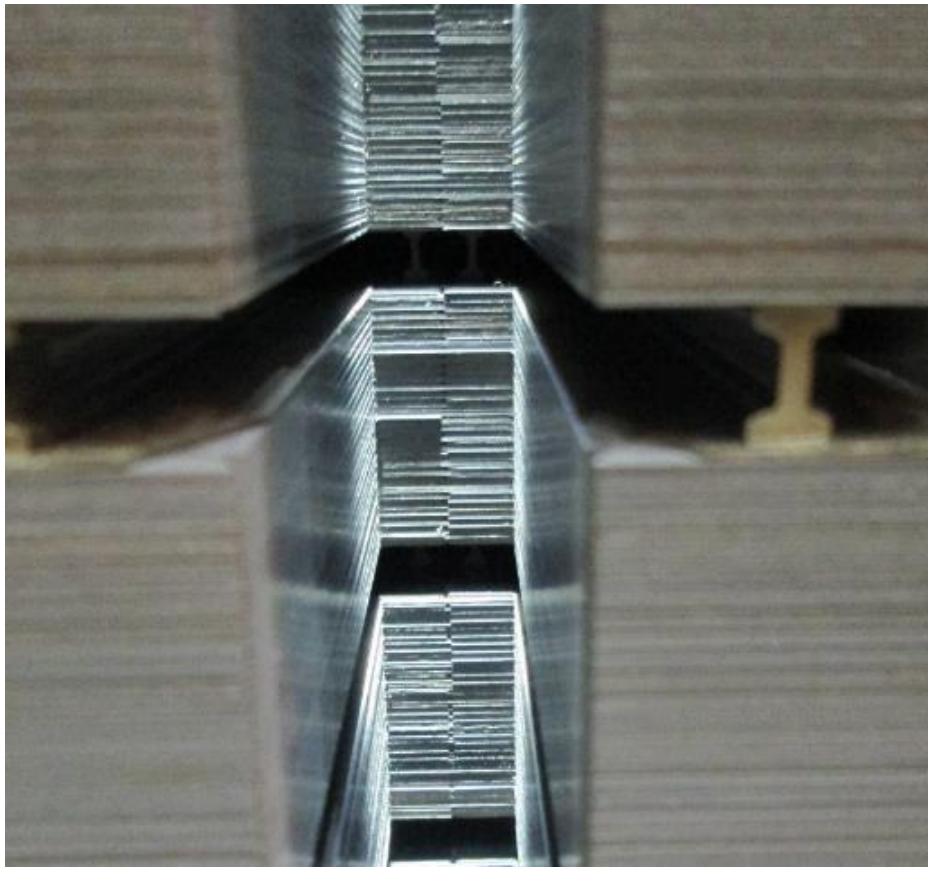
Problems with effectiveness of a particular grading paint additive led to spec requirement to use a better (and more expensive) additive, and then to tape instead.



SPECIFICATION DETAILS EVOLUTION

Problems at a different project led the Supplier to rework core laminations after they were punched.

Improper rework caused poor slot dimension control which led to spec requirement that laminations cannot be reworked after initial punching.



SPECIFICATION DETAILS EVOLUTION

Supplier used epoxy resin to secure slot closing wedges.
A winding installation error required the removal of several new bars.
Bars were damaged on removal as they were adhered to the slot due to resin weeping into slot.
This led to the spec requirement that epoxy resin cannot be used in the slot.

SPECIFICATION DETAILS EVOLUTION

Specifications required coils subjected to voltage endurance test to be dissected and inspected to assure no visible voids were present.

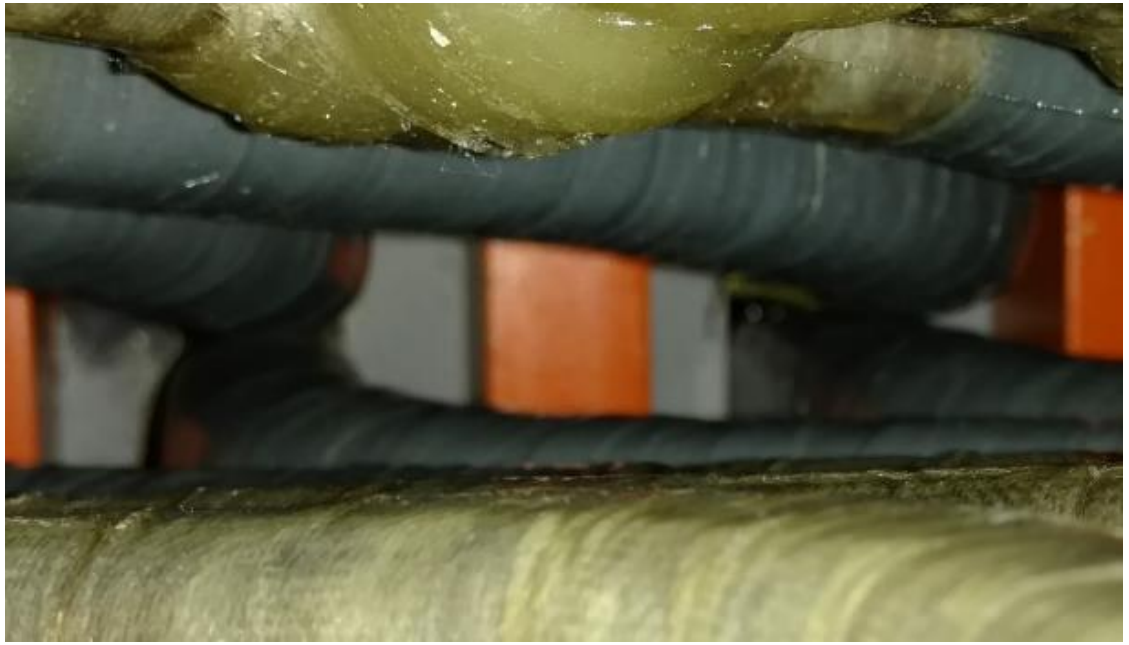
Several cases of coils and bars with voids present and subsequent technical discussion with Suppliers resulted in specification changes:

– Clarification of areas where voids are not allowed
– Clarification of the conditions under which dissection samples will be checked for voids

SPECIFICATION DETAILS EVOLUTION

Supplier had difficulty controlling shape of bar ends leading to:
– inadequate clearance at core exit
– inability to insert some top bars

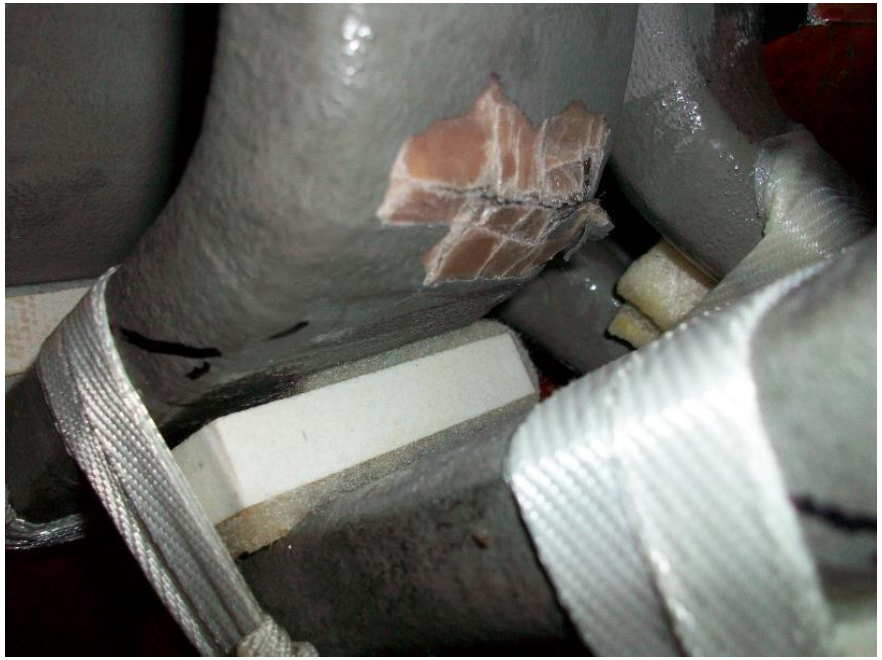
Led to revisions in spec requirements for bar fitment testing in dummy core sections in the factory.

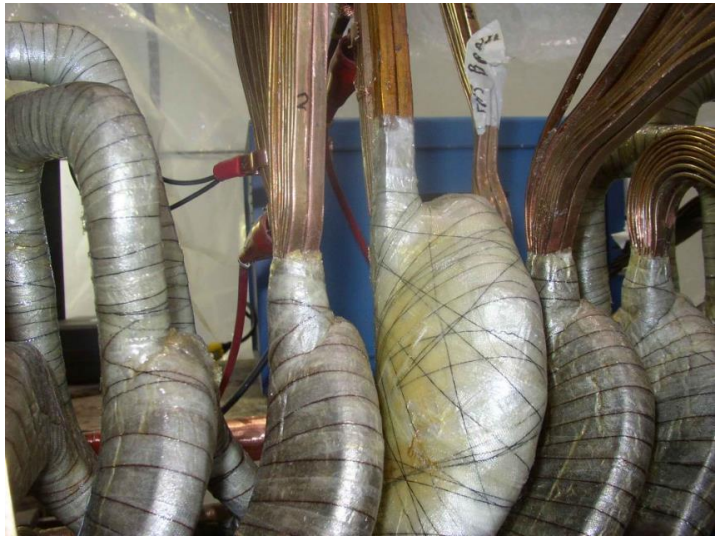


SPECIFICATION DETAILS EVOLUTION

Supplier failed to conduct adequate in-process testing during coil installation resulting in failure to detect a problem in a timely manner.

Led to more emphasis on in-process testing and monitoring.





CONCLUSION

Rewind specifications need to include sufficient detail to ensure the Owner receives what they expect in the rewind.

Rewind specifications should not limit the ability of the Supplier unnecessarily, and even then, the costs and other impacts of the limitation should be known to the Owner. These could possibly including one or more of

– higher cost
– lower ultimate generator output
– longer duration for work

– Pre-qualification of suppliers allows the Owner to determine whether the Supplier standard processes are acceptable and can allow a reduction in the level of detail in the specification.