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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



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Mr Chang Fu

Of interest to the following committees:

Horizontal function(s):

Aspects concerned:

Electromagnetic Compatibility

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Title:

Rules for steam turbine thermal acceptance tests - Part 4: Routine testing

Note from TC/SC officers:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS –

Part4: Routine testing

FOREWORD

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IEC 60953-4 has been prepared by subcommittee WG11/PT60953-4: Thermal Acceptance Test, of IEC technical committee 5: Steam Turbines.

The text of this International Standard is based on the following documents:

Draft	Report on voting
5/XX/FDIS	5/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This part of IEC 60953 is to be read in conjunction with IEC 60953-0:20220222, and the words 'routine test' should be read in place of 'acceptance test', the words 'reference conditions' should be read in place of 'guarantee conditions', the words 'reference value' should be read in place of 'guarantee value' as well. IEC 60953-0:2022 is taken as a Reference Standard.

A list of all parts in the IEC 60953 series, published under the general title Rules for steam turbine thermal acceptance tests, can be found on the IEC website.

323 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with
324 ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at
325 www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail
326 at www.iec.ch/standardsdev/publications.

327 The committee has decided that the contents of this document will remain unchanged until the stability date
328 indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the
329 document will be

- 330 • reconfirmed,
- 331 • withdrawn,
- 332 • replaced by a revised edition, or
- 333 • amended.

334

INTRODUCTION

Routine test in an existing power plant mainly involves an analysis, monitoring and supervision of steam turbine performance. IEC 60953-0, which defines the rules for steam turbine thermal acceptance tests in power plants, does not cater for all the requirements specific to routine test. It was considered necessary to draw up a Supplementary Standard (this document) for guidance on the routine tests of existing steam turbines.

However, a large number of the provisions and recommendations of IEC 60953-0 are still applicable to routine tests and, therefore, in order to avoid a repetitive and bulky document, only the routine-specific addenda will be found in this document.

This part of IEC 60953-4 shall be read in conjunction with IEC 60953-0, and the words 'routine test' should be read in place of 'acceptance test', the words 'reference conditions' should be read in place of 'guarantee conditions', the words 'reference value' should be read in place of 'guarantee value' as well.

Although this document is intended to apply to the routine test of large condensing steam turbines, it can nevertheless be used for other types and sizes of turbines to define the basis of a specific procedure to be agreed upon by the parties involved.

The purpose of this document is to cover the existing steam turbine components which influence the efficiency of the power plant. This document helps the parties determine the most appropriate parameters that characterise the relative performance change and that could be used as long-term performance monitoring and analysis.

The accuracy of the routine test can approach that obtained while following IEC 60953-0, but generally the simplified test results will yield less information about the plant and give less assurance of accuracy. The relative performance rather than absolute value is emphasized in this document. The repeatability of test result rather than test uncertainty is emphasized here as well. In addition depending on the type of test and thermodynamic boundary chosen, the full condition of each component might not be known. In some case, as per the result of routine test, full or further diagnostic test maybe needed.

For reference purposes only, a numerical sample calculation and analysis of a fossil steam turbine unit is presented in Annex I

The structure and clause numbering of this document follow that of IEC 60953-0. Subclauses found in this document supersede the whole of the equivalent subclause in IEC 60953-0. Subclause numbering has been extended whenever new items have been included.

The main differences between this document and the IEC 60953-0 are listed below.

Clause 1: Scope

This document gives additional clauses for routine test of steam turbine, regarding the analysis and supervision of relative performance by routine testing.

General principles and the determination of the measurement uncertainty of periodic routine tests are given.

The purpose of this document is to provide simple and economic test procedures guider for long-term and relative performance of the turbine and turbine cycles.

Specific simplified testing procedure is allowed, which results in less accuracy for absolute values and wider uncertainty range. The accuracy for the results of performance changes is sufficient for the purpose of the test.

378 Clause 2: Normative references

379 IEC 60953-0 and IEC 60953-3 were added as reference.

380 Clause 3: Units symbols, terms and definitions

381 The definitions given in IEC 60953-0 applies to this document. Some new definitions involved
382 features of routine testing were added.

383 Clause 4: Guidance principles

384 The majority of the guiding principles contained in the IEC 60953-0 are also applicable to the
385 routine testing. This document gives further guidelines on the planning, timing, leadership of
386 the tests, the setting of the test and cycle isolation, and allowable test conditions.

387 Clause 5: Measuring techniques and measuring instruments

388 According to the purpose and scope of routine test, the specific requirements of the
389 consistency of the test instruments, the calibration of the instruments and the usage of
390 permanently installed instruments are given.

391 Clause 6: Evaluation of tests

392 This document gives further advice on allowable cycle leakages.

393 Clause 7: Correction of test results and comparison

394 Additional considerations for routine test results comparison including performance
395 parameters trending and heat rate diagnosis are given.

396 Clause 8: Measuring uncertainty

397 This clause of IEC 60953-0 is supplemented by provisions for special cases encountered in
398 routine testing in Annex J. The examples can be used as reference basis.

399 Annexes:

400 Annexes A to E of IEC 60953-0:2022022 applies.

401 Six new annexes were added to the existing ones.

402 Annex F Guidance on selection a type of routine test to be performed.

403 Annex G: Sensitivity factors for some component performance on overall cycle efficiency

404 Annex H: Typical thermodynamic boundary and instrument layout for routine tests

405 Annex I: Calculation and analysis of test results – numerical example

406 Annex J: Numerical examples of uncertainty calculation – periodic comparative test

407 Annex K: Typical reasons for deviations of steam turbine performance from reference or
408 design level

409

RULES FOR STEAM TURBINE THERMAL ACCEPTANCE TESTS -

Part 4: Routine testing

1 Scope

1.1 General

This part of IEC 60953 establishes a Supplementary Standard for routine testing of steam turbines.

The rules given in this document follow the guidance given in IEC 60953-0, but contain amendments and supplements regarding the analysis and supervision of relative performance by routine testing of steam turbine.

General principles for the preparation, performance evaluation, trends of performance parameters and the determination of the measurement uncertainty of periodic routine tests are given in this document.

This document is applicable to routine testing covering a wide range of accuracy on steam turbines of every type, rating and application, operating with superheated or saturated steam.

The application of this standard to acceptance tests for new units or retrofit is not recommended, except for long term contract.

For online performance monitoring, this document can be used as a reference.

1.2 Object

The purpose of this document is to provide simple and economic test procedures for conducting, analysis and supervision of relative performance throughout the life of the turbine and turbine cycles.

The major purposes of routine testing are: a) to provide guidance in scheduling maintenance outage on the basis of performance; b) to detect or diagnose performance change in specific area of the turbine or turbine cycle c) to provide results for unit economic dispatch curves d) to provide relative magnitudes of losses in steam turbine cycle before priorities can be established to correct deficiencies.

Specific simplified testing procedure is recommended to minimize test instrumentation and personnel. Relative accuracy and wide uncertainty range rather than acceptance test level result are expected.

The repeatability of test result rather than test accuracy is emphasized here in this document.

Routine test results may include as follow:

a) Performance of the turbine and turbine cycle

1) Thermal efficiency or Heat rate;

2) Power output;

3) Steam rate;

4) Main steam flow capacity;

5) Nuclear: thermal load capacity of the steam turbine under defined conditions

b) Component performance and trending parameters

- 1) Turbine stage flow factors;
 - 2) Corrected turbine stage pressure;
 - 3) Cycle isolation;
 - 4) HP&IP turbine efficiency-expansion in superheated region;
- c) Heater, Deaerator, Condenser, Boiler Feedwater Pump (BFP) and BFP turbine;
- 1) Gland Leakage flow from HP to IP (for HP/IP combined turbine)

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60953-0:2022 Rules for steam turbine thermal acceptance tests – Part 0: Wide range of accuracy for various types and sizes of turbines.

IEC 60953-3: 2023 Rules for steam turbine thermal acceptance tests – Part 3: Thermal performance verification tests of retrofitted steam turbines.

3 Units, symbols, terms and definitions

Subclause IEC 60953-0 2022 3.0 applies.

3.1 General

Subclause of IEC 60953-0:2022— 3.1 applies

3.2 Symbols, units

Subclause of IEC 60953-0:2022— 3.2 applies

3.3 Subscripts, superscripts and definitions

Subclause of IEC 60953-0:2022— 3.3 applies

3.3.1 Reference condition

The values of all the external parameters, i.e., parameters outside the test boundary to which the test results are corrected. Reference conditions might be the boundary conditions of design or reference test.

3.3.2 Reference test

Test carried out under reference condition, the result was used for comparing the performance change and diagnosing deficiency.

The reference test can be the original guarantee verification test, any other periodic test, or information from the manufacturer's heat balances or tests before or after overhaul. In order that a meaningful comparison be made between the tests. It is necessary that the conditions at the measurement boundary are the same.

The result of reference test could be used as reference/baseline performance.

3.3.3 Comparative test

Current test or a series of tests carried out in order to prove a relative change of performance, relative to the reference test.

This kind of test could be carried out periodically or for specific purpose. such as before or after a major overhaul.

3.3.4 Repeatability

The ability of the measurement system to produce test results of the same output/input relationship over extended time periods.

Repeatability is essential in periodic test so that variations in performance indicated by test results are true indications of the deterioration of the equipment tested.

3.3.5 Primary parameters

Measured variables which significantly affect the test result, should be measured with instruments of a known calibration status.

3.3.6 Secondary parameters

Measured variables which have a minor effect on test result.

3.4 Definition of routine test results

3.4.1 Guidance on routine performance parameters

Subclause of IEC 60953-0:2022— 3.4.1 applies

3.4.2 Thermal efficiency

Subclause of IEC 60953-0:2022— 3.4.2 applies

3.4.3 Heat rate

Subclause of IEC 60953-0:2022— 3.4.3 applies

3.4.4 Thermodynamic efficiency

Subclause of IEC 60953-0:2022— 3.4.4 applies

3.4.5 Steam rate

Subclause of IEC 60953-0:2022— 3.4.5 applies

3.4.6 Main steam flow capacity

Subclause of IEC 60953-0:2022— 3.4.6 applies

3.4.7 Power output

Subclause of IEC 60953-0:2022— 3.4.7 applies

3.4.8 Guarantee values for extraction and mixed-pressure turbines¹

Subclause of IEC 60953-0:2022— 3.4.8 applies

3.4.9 Thermal Load Capacity (for Nuclear applications)

Subclause of IEC 60953-0:2022— 3.4.9 applies

3.5 Additional definition of routine test results

3.5.1 Turbine efficiency -Expansion in superheated region

Turbine efficiency gives a measurable indication of bulk efficiency of steam expansion in terms of the ratio of actual enthalpy drop to isentropic enthalpy drop. When the steam is superheated at inlet(tp) and outlet(out), the corresponding enthalpies may be derived directly from pressure and temperature measurements.

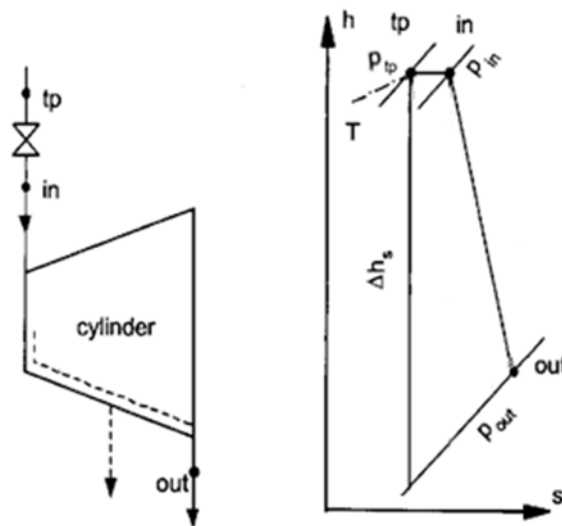


Figure 1 – Isentropic efficiency of cylinder

Turbine efficiency:

$$\eta_{cyl} = \frac{h_{tp} - h_{out}}{\Delta h_s} \quad (1)$$

The condition at “tp” is before the inlet valves, indicating that the turbine efficiency includes valve pressure loss. The condition at “out” usually includes returned and mixed ‘balance-piston’ leakage where measurements are taken before the steam is routed back to the boiler, another turbine or steam consumer.

Special care should be paid to the pressure and temperature measurements of the inlet and outlet of turbine. The measurement points and instruments should be consistent for reference test and subsequent comparative test.

3.5.2 Turbine stage flow factor

Turbine stage flow factor is constant as a function of flow to the following stage.

The stage flow constant k, is an indicator of stage nozzle area changes when plotted against throttle flow.

¹ Mixed pressure turbines - several inlets at different pressures during the expansion.

$$k = \frac{\frac{\dot{m}_{in}}{\sqrt{P_{in}/v_{in}}}}{\sqrt{1 - (P_{out}/P_{in})^2}} \quad (2)$$

537

538 where

539 k flow constant;

540 P_{in} pressure (absolute) to the stage;541 P_{out} pressure (absolute) leave the stage;542 V_{in} specific volume to the stage;543 $\dot{m}_{in}$ flow to the stage.

544 For expansion beyond choked pressure ratio, the formula (1) expression simplifies to:

$$k = \frac{\dot{m}_{in}}{\sqrt{P_{in}/v_{in}}} \quad (3)$$

545 For the turbine using wet steam, (4) apply.

$$= \frac{\dot{m}_{in}/\sqrt{P_{in}/v_{in}}}{\sqrt{1 - x}} \quad (4)$$

546 Where

547 x moisture fraction of the steam.

548 Information pertinent to the internal conditions of the turbine is provided using the turbine flow
 549 factor equation. Although this relationship is not accurate if changes in local areas occur, it
 550 can be used to recognize that a change has occurred and to help estimate the magnitude of
 551 that change.

552 In addition, it can also be used to calculate shaft-packing and valve stem leakoff flows. The
 553 constant is calculated from acceptance or design data, and the calculated flow may be
 554 compared against the actual measured values to determine the location of the steam seal
 555 damage.

556 3.5.3 Corrected Turbine stage pressures

557 Turbine stage and shell pressures require correction for departure from reference steam
 558 conditions.

559 The first-stage pressure on the HP section of a reheat turbine, or the stage or shell pressure
 560 for any stage of a non-reheat turbine shall be corrected to reference conditions by the
 561 equation:

$$P_c = P_0 \times (P_d/P_t) \quad (5)$$

562

563 where

564 P_c is the corrected pressure for plotting, MPa;565 P_0 is the test stage or shell pressure, MPa;566 P_d is the design, or reference, throttle pressure, MPa;

567 P_t is the test throttle pressure, MPa.

568 This equation also applies to an intermediate stage extraction in the HP turbine section.

569 For stage or shell pressures at or following the inlet to the reheat turbine section and for the
570 exit from the last stage of the HP section, the correction equation becomes:

$$P_c = P_0 \sqrt{\frac{P_d}{P_t} \times \frac{V_t}{V_d} \times \frac{V_{dr}}{V_{tr}}} \quad (6)$$

571 where

572 V_t is the test throttle specific volume, m³/kg;

573 V_d is the design or reference throttle specific volume, m³/kg;

574 V_{dr} is the specific volume at design reheat temperature and test pressure at inlet to reheat
575 stop valves, m³/kg;

576 V_{tr} is the specific volume at test temperature and test pressure at inlet to reheat stop valves,
577 m³/kg.

578 **3.5.4 Heat rate and power output characteristic**

579 The heat rate tested on the selected condition may be plotted to trend turbine performance.
580 Heat rate could be plotted as a function of power output. Any heat rate and power output must
581 be corrected for deviations from reference throttle steam condition, reheat steam conditions,
582 exhaust pressure and other cycle characteristics.

583 The trend (or curve) could be accumulated over time, which may establish data for long term
584 performance comparisons, also for diagnosing performance change.

585 **3.5.5 Heat input and power output characteristic**

586 The plotting of heat input to turbine cycle versus power output is a useful tool for
587 determination and monitoring the performance of turbine. The relationship will be linear
588 extrapolation to the heat input axis, due to a minimum thermal heat required to overcome no-
589 load losses (about 3% of full-load value). This characteristic is known as Willans line.

590 **3.5.6 Component performance**

591 **3.5.6.1 Feed water Heater performance parameters**

592 a) Terminal Temperature Difference (TTD)

593 TTD is the difference between the saturation temperature corresponding to the steam inlet
594 pressure and the feed water heater outlet temperature.

$$TTD = T_s - T_{fo} \quad (7)$$

595

596 where

597 T_s is the saturated water temperature, corresponding to heater steam inlet
598 pressure, °C;

599 T_{fo} is the feed water heater outlet temperature, °C.

600 b) Drain Cooler Approach (DCA)

DCA is the difference between drain outlet temperature and feedwater heater inlet temperature.

$$DCA = T_d - T_{fi} \quad (8)$$

where

T_d is the drain cooling zone or external drain cooler outlet temperature, °C;

T_{fi} is the feed water heater inlet temperature, °C.

3.5.6.2 Condenser performance

Condensate sub-cooling (condensate depression) is the degree to which the condensate has been cooled below the saturation temperature corresponding to the measured condenser shell side pressure.

$$\Delta T_s = T_s - T_{co} \quad (9)$$

where

ΔT_s is the condensate sub-cooling, °C

T_s is the saturated water temperature, corresponding to the condenser shell side pressure, °C;

T_{co} is the Condensate temperature, °C.

3.5.6.3 Boiler Feedwater Pump(BFP) and BFP turbine performance

a) BFP enthalpy rise

The energy absorbed by the water through the pump is usually expressed as the boiler feedwater pump enthalpy rise. Normally, the ratio of the extraction water flow rate from the intermediate stage of the feed water pump and sealing water flow rate to the main feed water flow rate is quite small, and the BFP enthalpy rise can be simply expressed as:

$$\Delta h_{er} = h_{fw,out} - h_{fw,in} \quad (10)$$

where

Δh_{er} is the BPF enthalpy rise *kJ/kg*;

$h_{fw,in}$ is the inlet water enthalpy of feed water pump, *kJ/kg*;

$h_{fw,out}$ is the outlet water enthalpy of feed water pump, *kJ/kg*.

b) Power equivalent of the enthalpy rise of the water flow through the pump

The power equivalent of the enthalpy rise of the water flow through the pump (P_{er}) is:

$$c) P_{er} = \dot{m}_{fw}(h_{fw,out} - h_{fw,in}) - \dot{m}_{fw,ex}(h_{fw,out} - h_{fw,ex}) + \dot{m}_{sw,in}(h_{fw,out} - h_{sw,in}) - \dot{m}_{sw,out}(h_{fw,out} - h_{sw,out}) \quad (11)$$

where

P_{er} is the power equivalent of the enthalpy rise of the water flow through the pump *kW*,

- 633 $\dot{m}_{fw}$ is the inlet water flow rate of feed water pump (excluding sealing water), kg/s;
 634 $\dot{m}_{fw,ex}$ is the extraction water flow rate from the intermediate stage of the feed water
 635 pump, kg/s;
 636 $\dot{m}_{sw,in}$ is the inlet sealing water flow rate of feed water pump, kg/s;
 637 $\dot{m}_{sw,out}$ is the outlet sealing water flow rate of feed water pump, kg/s;
 638 $h_{fw,ex}$ is the extraction water enthalpy of feed water pump, kJ/kg;
 639 $h_{sw,in}$ is the inlet sealing water enthalpy of feed water pump, kJ/kg;
 640 $h_{sw,out}$ is the outlet sealing water enthalpy of feed water pump, kJ/kg.

641 d) BFP turbine inlet steam flow

642 The difference between the test and the specified cycle extraction flow to the BFP turbine will
 643 affect the performance of the turbine, and heat rate and power should be corrected
 644 accordingly. Extraction flow is usually expressed in percent of throttle flow and plotted versus
 645 the extraction pressure to generalize its application.

646 BFP turbine exhaust pressure should be measured and used to correct the BFP turbine inlet
 647 steam flow if correction factor for exhaust pressure not include the effect on the auxiliary
 648 turbine. If BFP is driven by condensing auxiliary turbine and there is a difference between test
 649 and specified exhaust pressure, it would be necessary to assess how much of the difference
 650 in auxiliary turbine steam flow between test and specified is due to the change in exhaust
 651 pressure and correct only for the remainder. A convenient way is to obtain a corrected
 652 auxiliary turbine extraction flow by multiplying the specified extraction flow by the ratio of
 653 available energy on the auxiliary turbine at specified conditions to the available energy at test
 654 conditions.

655 Note: This section is suitable for steam driven pump.

656 4 Guiding principles

657 4.1 Advance planning for test

658 Subclause of IEC 60953-0:2022—4.1 applies with the following additions.

659 In planning the routine test, the parties to the tests shall reach an agreement concerning the
 660 testing type(See Annex F), procedure, the number, location and arrangement of measuring
 661 points and measuring devices (See Annex H) , valves and piping arrangements, with due
 662 consideration given to the cost of the routine tests. Special care shall be given to the following:

- 663 a) The test procedure shall remain unchanged in the subsequent comparative tests.
- 664 b) The instrumentation shall be selected to achieve test results with good repeatability.
 665 Simplify test instruments to minimize test costs.
- 666 c) Consistency of settings of tests, tapping points, instruments and calibration standards.
- 667 d) In terms of routine tests, these may be used throughout whole life of the steam turbine, A
 668 reference test result shall be selected as a bench mark for current performance and other
 669 subsequent comparative tests conducted to monitor the deviation. The reference test can
 670 be the original guarantee verification test, any other subsequent comparative test, or
 671 information from the manufacturer's heat balances or tests before or after overhaul. In
 672 order that a meaningful comparison be made between the tests. It is necessary that the
 673 test boundary conditions are consistent (See Annex H) , should they differ appropriate
 674 corrections shall be applied. The method of correction for the reference test and
 675 subsequent tests shall be the same.

676 4.2 Preparatory agreements and arrangements for tests

677 Subclause of IEC 60953-0:2022—4.2 a) through k) applies:

4.3 Planning for test

4.3.1 Time for routine test

- a) Routine test can be carried out at any time if necessary.
- b) It is recommended to conduct the routine test at regularly scheduled intervals, at least once a year.
- c) For unit overhaul, it is recommended to conduct tests before and after overhaul respectively.

4.3.2 Direction of routine tests

Subclause of IEC 60953-0:2022—4.3.2 is not applicable.

The responsibility for the routine tests shall be assigned prior to the test, preferably to one person. This person is responsible for proper execution and evaluation of the routine tests, and serves as leader and coordinator in the event as to the accuracy of observations, conditions, or methods of operation. He is entitled and obliged to obtain information on all necessary details. His responsibility is mainly as follow but not limited to:

- a) Make decision on technical issues
- b) Preparing the test procedure and relevant documents
- c) Arrange the responsibilities of each tester
- d) Pronouncing of beginning and ending of a test
- e) Coordinate operators to adjust to the required operating conditions
- f) Preside over the report meeting before and after the test
- g) Make a decision about the abnormal situation during the test
- h) Calculate and evaluate the test result
- i) Complete the report and reports to the person who assigned the task
- j) Test parties may include performance engineers, operators, maintenance staff etc.

4.4 Preparation of the tests

4.4.1 Condition of the plant

Prior to commencement of the routine tests, it is essential to be satisfied that the steam turbine and driven machine are in suitable condition, together with the condenser and/or feedheaters if included in the test scope. It is also essential to verify that leaks in the condensers, feedheaters, pipes and valves have been eliminated.

Prior to the routine tests, an opportunity shall be given to test engineers to check the condition of the plant. Any deficiency determined at this time shall be rectified as far as practicable. If in case one of the components was defected or out of service, test could be conducted for considering the proper correction.

In setting up turbine cycle and component equipment for testing, all conditions influencing the test results should duplicate as close as possible those conditions specified in design or reference. Flows not indicated by design/reference conditions should be shutdown and isolated.

Controllable steam conditions should be adjusted to levels as close as possible to design or reference values.

4.4.2 Condition of the steam turbine

Subclause of IEC 60953-0:2022—4.4.2 applies