Guideline No.: J-01 (202407)

J-01

WELDING CONSUMABLES

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Foreword

China Classification Society (hereinafter referred to as CCS) Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed mp@ccs.org.cn.

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Main changes:

1. According to the CCS "Rules for Materials and Welding" amendments, some contents of the guidelines are revised to be consistent with the Rules.

2. Revise the inspection requirements of welding flux according to the revision of national standards.

CONTENTS

WELDING CONSUMABLES

1 Application

1.1 This Guideline applies to the works approval and unit/batch inspection of the following welding consumables such as electrodes, wires and fluxes intended for use in the welding of metallic structures of ships and relevant products:

(1) Electrodes for manual arc welding of structural steel;

(2) Wire-flux combinations for submerged arc automatic welding for structural steel;

(3) Wires and wire-gas combinations for manual, semi-automatic and automatic welding of structural steel;

(4) Consumables for use in electro-slag or electro-gas vertical welding of structural steel;

(5) Consumables for use in one-side welding with temporary backing materials of structural steel;

(6) Welding consumables for stainless steel;

(7) Welding consumables for aluminum alloys;

(8) Fluxes.

2 Normative references

CCS Rules for Materials and Welding.

3 Terms and definitions

Nil.

4 Drawings and documents

4.1 The manufacturer of welding consumables is to submit an application for approval, describing clearly the designation (each designation of wire-flux combinations for submerged arc welding; type of gas for gas shielded arc welding wires), specification, grade, level of hydrogen content (where applicable), applicable welding position, applicable welding current type and/or current polarity.

4.2 The following are to be submitted to CCS for review.

4.2.1 Source of raw materials and technical specification: list of suppliers (such as wire rods, steel tapes and mineral powder) and technical specification of raw materials, such as chemical composition and mechanical properties of wire rods and steel tapes, grain size, appearance, sampling and testing methods of mineral powder.

4.2.2 Information on main production, inspection and test equipment: name, purpose, type (specification), capacity and equipment supplier. The manufacturer is to have appropriate equipment and qualification for unit/batch inspection.

4.2.3 Production and inspection procedure, main technical documents (the coating type, formulation design documents, slag system).

4.2.4 Manufacturer's instructions:

(1) Electrodes: designation (type), grade, purpose, chemical composition and mechanical properties of deposited metal, drying temperature and time before use, recommended welding parameters;

(2) Wires (solid and flux-cored wires): designation (type), grade, purpose, chemical composition of deposited metal, mechanical properties of deposited metal, reference data (welding amperage, welding voltage), applicable gas components and gas flow, designation (type) of compatible flux;

(3) Fluxes: designation (type), grade, purpose, type (melted, sintered), slag system, components, current, polarity, drying temperature and time before application.

4.3 The test program is to be submitted to CCS for approval.

5 Technical requirements

The manufacture and inspection of welding consumables are to comply with the requirements of Chapter 2, PART THREE of the CCS Rules for Materials and Welding.

6 Materials and components

6.1 The manufacturer of welding consumables such as marine electrodes, wires and fluxes is to obtain works approval by CCS.

6.2 Wire rods and steel tapes for welding consumables are to be supplied by manufacturers recognized by CCS.

7 Type test

7.1 Type test program

7.1.1 The program may be proposed by the manufacturer and submitted to CCS for approval, or proposed by CCS and confirmed by the manufacturer in written form before execution.

7.1.2 The manufacturer is to clearly state the applicable welding positions of consumables. CCS is to state the approved welding positions in the certificate of works approval, for instance, down hand (F), horizontal (H), vertical upward (Vu), vertical downward (Vd) or overhead (O).

7.1.3 Development of test program

(1) Electrodes: the test program is to be developed based on the designation (type), specification and approved grade of the electrodes for approval in accordance with Chapter 1 and Chapter 2 of PART ONE, Chapter 1 and Section 3, 8 and 9 in Chapter 2 of PART THREE of CCS Rules for Materials and Welding respectively;

(2) Wires: the test program is to be developed based on the designation (type), specification and approved grade of the wires for approval in accordance with Chapter 1 and Chapter 2, PART ONE, and Chapter 1 and Section 4, 5, 6, 8 and 9 in Chapter 2, PART THREE of CCS Rules for Materials and Welding respectively;

(3) Fluxes: the test program is to be developed in accordance with Chapter 1 and Chapter 2 of PART ONE, and Chapter 1 and Section 4 in Chapter 2 of PART THREE of CCS Rules for Materials and Welding.

7.2 Place of test

7.2.1 The test samples are to be submitted to independent laboratory approved or recognized by CCS for complete or part test in the following circumstances:

(1) The initial approval for manufacturer;

(2) Evaluation of the reliability of type test for manufacturer in present conditions;

(3) The manufacturer doesn’t have conditions for type test;

(4) The Surveyor deems necessary.

7.2.2 In addition to the above, where the manufacturer has adequate inspection and test equipment to satisfy the requirements of CCS for effectiveness and accuracy of test result, and has qualified test personnel, the type test may be carried out in the laboratory of the manufacturer with consent of CCS. In the test items, at least one item for routine (delivery) inspection of relevant consumables is to be carried out in the laboratory of the manufacturer.

7.3 Base material for test

7.3.1 For structural steel consumables, the manufacturer is to provide for approval the steel plate of grade specified in Section 1, Chapter 2 of PART THREE of CCS Rules for Materials and Welding. Selection of a toughness grade lower than that required in the Table may be allowed. The steel plate is to be satisfactorily inspected by CCS. Any grade of marine structural steel may be used for the preparation of deposited metal test assemblies made from the consumables for welding the structural steels. Replacement of plates is to be subject to approval by CCS.

7.3.2 The welding consumables for stainless steel plate are to be selected in accordance with the requirements in Section 8, Chapter 2, PART THREE of CCS Rules for Materials and Welding.

7.3.3 The welding consumables for aluminum alloy plate are to be selected in accordance with the requirements in Section 9, Chapter 2, PART THREE of CCS Rules for Materials and Welding.

7.3.4 In deposited metal test, where the strength or chemical composition of the base material used for approval is different from that of the consumables, transitional layers may be adopted on the prepared edges and surface of backing plates. The thickness of the layer is not to be less than 3 mm. The manufacturer is to submit test assembly diagram and dimension to CCS for approval.

7.4 Preparation of test assembly

7.4.1 The manufacturer is to develop a table indicating the number of test specimens, including designation (type), welding positions, specification and number. The number of test specimen is to be kept from welding of the assembly to finishing of the test specimen, otherwise, the test assembly is to be rejected and a new one is to be welded.

7.4.2 During type tests, the preparation and testing of the test specimens are to be carried out in the presence of CCS Surveyor. It is recommended that NDT be carried out after welding of test assembly to ascertain that no defect exists in the welds which will affect the accuracy of the tests. After welding, test assemblies are not to be subject to any heat treatment, except the deposited metal longitudinal tensile test specimens. Heat treatment for hydrogen removal is not to be applied

to the deposited metal longitudinal tensile test specimens of low hydrogen consumables.

7.4.3 The welding conditions such as amperage, voltage, traveling speed, etc. are to be within the range recommended by the manufacturers. In case of multi-run layers, the direction of deposition of each layer is to change from each end of the plate. The test in the welding of assembly is to be recorded for Surveyor to examine. Where some material is applicable to both alternating current and direct current, the alternating power supply is to be adopted in preparation of specimens.

7.4.4 The test assembly may be restrained or subject to initial distortion prior to welding to prevent angular distortion. Where the warping due to the welding exceeds an angular distortion of 5 degrees, the test assembly is to be discarded. The test assembly after welding is not to be subject to any straightening (hammered or flattened).

7.4.5 In preparing test assembly, the mark of CCS stamp is to be transferred in the presence of the Surveyor.

7.4.6 The prepared test assembly is to be in accordance with the relevant requirements in PART ONE and PART THREE of CCS Rules for Materials and Welding.

7.5 Test

7.5.1 The test equipment is to have calibration certificate within validity issued by statutory metrological agency.

7.5.2 The proportion of V-notch drawing for check of impact test specimens is to be not less than 50:1. The drawing is to be checked by statutory metrological agency and a calibration certificate is to be provided.

7.5.3 The tensile test, bend test, impact test, fillet weld fracture test, macro-examination and hardness tests in the manufacturer are to be carried out in the presence of the Surveyor. The preparation of hydrogen test specimens and the readings in the manufacturer are to be carried out in the presence of the Surveyor. The specification of the stainless steel specimen for corrosion test is to be examined by the Surveyor. The preparation of corrosive medium and the bending and flattening tests of the specimens are to be carried out in the presence of the Surveyor.

7.5.4 An analysis report of chemical composition of the deposited weld metal (including content of all significant alloy elements) is to be submitted by the manufacturer.

7.5.5 Determination of diffusion hydrogen content in deposited metal by mercury method and thermal conductivity hot carrier gas extraction method should be carried out on the basis of

standard ISO 3690, and meet the following requirements:

(1) For determination of diffusion hydrogen content in deposited metal by mercury method, diffusion hydrogen collection will be not less than 72 hours. From the 48th hours, gas volumes should be measured and recorded every 24 hours. Corrected to standard temperature and pressure, i.e. 0℃ and 101.325kPa, a change of no more than 1 % of the total volume collected can be understood determination of diffusion hydrogen content is finished, namely:

$$(V_n-V_{n-1}) / V_{n-1} \times 100\% \leqslant 1\%$$

where

V_n is the measured volume of escaped gas in 24 hours of the n-th after the test;

V_{n-1} is the measured volume of escaped gas in 24 hours of the n-1-th after the test.

(2) For determination of diffusion hydrogen content in deposited metal by thermal conductivity hot carrier gas extraction device, the test should meet:

① The data and/ or curve of escaped diffusion hydrogen can be recorded and displayed continuously by the device, and the data and/ or curve of escaped diffusion hydrogen can be displayed directly in volume while it is feasible;

② Measurement time of diffusion hydrogen is not less than 30mins anytime. From the 27th minute, diffusion hydrogen collection can be finished if a change of the total volume of diffusion hydrogen in every 3mins is not more than 1%;

Or the total of the shortest analysis time and the longest compensation time set for determination of diffusion hydrogen meets the following requirements: not less than 1.5h to ISO test pieces A, and not be less than 1h to ISO test pieces B;

③ In the quartz tube, the actual degassing temperature on the sample is not more than 400℃;

④ There are clear calibration methods to the test instrument in the laboratory, including the calibration procedure of the gas calibration unit, and the test procedure of the temperature deviation of the simulated sample.

7.6 Type test items and requirements

7.6.1 The number of electrodes for manual arc welding of structural steel is to comply with the requirements in 2.3.2, PART THREE of CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.1. The diameter of electrodes is to be selected in accordance with 2.3.3 and 2.3.4 respectively of PART THREE of CCS Rules for Materials and Welding. In general, two deposited metal test assemblies are to be prepared. One assembly is made with 4 mm diameter electrodes and the other with the largest size manufactured, if electrodes are available in one diameter only, one test assembly is sufficient. The selection of electrodes for down hand butt weld tests is as follows: first run with 4 mm diameter electrode, remaining runs (except the last two layers) with 5mm diameter electrodes. The runs of the last two layers with the largest diameter of the same type of electrode manufactured.

Test items and requirements for structural steel electrodes for manual arc welding

Table 7.6.1

Serial No.	Test items	Content	Result
1	Deposited metal tests and chemical composition analysis	2.3.3 of PART THREE OF CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding; chemical composition analysis is to comply with standards accepted by CCS
2	Butt weld tests	2.3.4 of PART THREE OF CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding
3	Fillet weld tests	2.3.5 of PART THREE OF CCS Rules for Materials and Welding	In accordance with 2.3.5.3 of PART THREE of CCS Rules for Materials and Welding
4	Hydrogen test (if required)	2.3.6 of PART THREE OF CCS Rules for Materials and Welding	In accordance with Table 2.3.1.1 and Table 2.3.6.3 of PART THREE of CCS Rules for Materials and Welding

7.6.2 The quantities of test assembly for welding consumables for stainless steel are to comply with the requirements in Section 8, Chapter 2, PART THREE of CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.2.

Test items and requirements for welding consumables for stainless steel

Table 7.6.2

Serial No.	Test items	Content	Result
1	Deposited metal tests and chemical composition analysis	Deposited metal tests and chemical composition and Welding	Mechanical properties are to be in accordance with Table 2.8.3.4 of PART THREE of CCS Rules for Materials and Welding; chemical composition analysis is to comply with standards accepted by CCS
2	Butt weld tests	2.8.4 of PART THREE OF CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.8.4.3 of PART THREE of CCS Rules for Materials and Welding
3	Fillet weld tests	2.3.5.3 of PART THREE OF CCS Rules for Materials and Welding	In accordance with 2.3.5.3 of PART THREE of CCS Rules for Materials and Welding
4	Measurement of ferrite content of deposited metal	2.8.3.5 of PART THREE OF CCS Rules for Materials and Welding	In accordance with 2.8.3.5 of PART THREE of CCS Rules for Materials and Welding
5	Intercrystalline corrosion test for butt joints	According to Section 7, Chapter 2, PART ONE of CCS Rules for Materials and Welding	
6	Pitting corrosion test of duplex stainless steel for butt joints	According to Section 9, Chapter 2, PART ONE of CCS Rules for Materials and Welding	

7.6.3 The quantities of test assembly for welding consumables for aluminum alloy are to comply with the requirements in Section 9, Chapter 2, PART THREE of CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.3.

Test items and requirements for welding consumables for aluminum alloy

Table 7.6.3

Serial No.	Test items	Content	Result
1	An analysis of chemical composition of the deposited weld metal	2.9.3.2 of PART THREE OF CCS Rules for Materials and Welding	The report is to include content of all significant elements. The test results are not to exceed the limit values specified by the manufacturer
2	Butt weld test	2.9.3.4 of PART THREE OF CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.9.3.7 of PART THREE of CCS Rules for Materials and Welding

7.6.4 The quantities of test specimens for wire-flux combinations for submerged arc automatic welding are to comply with the requirements in Section 4, Chapter 2, PART THREE of CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.4.

Test items and requirements for wire-flux combinations for submerged arc automatic welding

Table 7.6.4

Serial No.	Test items	Content	Result
1	deposited metal test for use with multi-run technique and chemical composition analysis	2.4.3 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding; chemical composition analysis is to comply with standards accepted by CCS
2	Butt weld tests for use with multi-run technique	2.4.4 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding
3	Butt weld tests for two-run technique	2.4.5 of PART THREE of CCS Rules for Materials and Welding	
4	Hydrogen test (if required)①	2.3.6 of PART THREE of CCS Rules for Materials and Welding	In accordance with Table 2.3.1.1 and Table 2.3.6.3 in Section 3, Chapter 2, PART THREE of CCS Rules for Materials and Welding

Note: ① Where welding consumables are intended to be used for high strength steel used for welding structures with a yield stress of 420 N/mm^2 and above, a hydrogen test is to be carried out in accordance with the method specified by CCS.

7.6.5 The quantities of test specimens for wires and wire-gas combinations for manual, semi-automatic and automatic welding is to comply with the requirements in Section 5, Chapter 2, PART THREE of CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.5.

Test items and requirements for wires and wire-gas combinations for manual, semi-automatic and automatic welding

Table 7.6.5

Serial No.	Test items	Content	Result
1	Deposited metal tests for semi-automatic multi-run technique and chemical composition analysis	2.5.3 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding; chemical composition analysis is to comply with standards accepted by CCS
2	Deposited metal tests for automatic multi-run technique and chemical composition analysis	2.5.6 of PART THREE of CCS Rules for Materials and Welding	
3	Butt weld tests for semi-automatic multi-run welding	2.5.4 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding
4	Butt weld tests for automatic multi-run technique	2.5.6 of PART THREE of CCS Rules for Materials and Welding	
5	Butt weld tests for two-run automatic welding	2.5.7 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding
6	Fillet weld tests for semi-automatic multi-run technique	2.5.5 of PART THREE of CCS Rules for Materials and Welding	In accordance with Table 2.3.5.3 of PART THREE of CCS Rules for Materials and Welding
7	Hydrogen test (if required)	Refer to 2.3.6 of PART THREE of CCS Rules for Materials and Welding	In accordance with Table 2.3.1.1 and Table 2.3.6.3 of PART THREE of CCS Rules for Materials and Welding

Note: ① The grouped shielding gas is to be subjected to type test respectively.

② The composition of the shielding gas used in the type test is to be reported, and the group and composition limits of shield gas are given in table 2.5.1.3 in Chapter 2, PART THREE of CCS Rules for Materials and Welding.

③ For group C1, single shielding gas CO_2, the purity of shielding gas CO_2 should be not less than 99.8% in volume. The purity of other shielding gases refers to ISO 14175.

④ The wires and the wire-gas combinations used in manual tungsten inert gas (TIG) welding are to be subject to approval tests in accordance with semi-automatic multi-run welding.

7.6.6 The quantities of test specimens for Consumables for use in electro-slag and electro-gas vertical welding is to comply with the requirements in Section 6, Chapter 2, PART THREE of

CCS Rules for Materials and Welding. Detailed test items and requirements are given in Table 7.6.6.

Test items and requirements for consumables for use inelectro-slag and electro-gas vertical welding

Table 7.6.6

Serial No.	Test items	Content	Result
1	Butt weld tests	2.6.2 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding

7.6.7 Test items and requirements for fluxes are given in Table 7.6.7(1).

Test items and requirements for fluxes

Table 7.6.7(1)

Serial No.	Test items	Result
1	wire-flux combinations for submerged arc automatic welding and wire-flux combinations electro-slag welding	Mechanical properties of deposited metal for wires combined (CCS grade)
2	Grain size	Flux can be supplied in different grain size ranges. The total amount of coarse and fine particles exceeding the grain size range should not exceed 10% (mass fraction). The grain size of the flux is shown in Table 7.6.7 (2)
3	Content of water	≤ 0.10%
4	Mechanical inclusion	≤ 0.30%
5	Content of sulphur	≤ 0.050%
6	Content of phosphorus	≤ 0.060%

Flux grain size code

Table 7.6.7(2)

Grain size code	Grain size mm	Common sieve mesh for reference（Sieve size） mesh (mm)
25	2.5	8 (2.36)
20	2.0	10 (2)
16	1.6	12 (1.7)
14	1.4	14 (1.4)
12	1.25	16 (1.18)
8	0.8	20 (0.850)
5	0.5	35 (0.500)
4	0.4	40 (0.425)
3	0.315	50 (0.300)
2.5	0.250	60 (0.250)
2	0.2	70 (0.212)
1	0.1	140 (0.106)
0	＜0.1	—

7.6.8 The test items and requirements for consumables for use in one-side welding with temporary backing materials are given in Table 7.6.8.

Test items for consumables for use in one-side welding with temporary backing materials

Table 7.6.8

Serial No.	Test items	Content	Result
1	Butt weld test for wire-gas combinations for use with manual, semi-automatic multi-run techniques	2.7.2 of PART THREE of CCS Rules for Materials and Welding	Mechanical properties are to be in accordance with Table 2.2.2.3 of PART THREE of CCS Rules for Materials and Welding
2	Butt weld test for wire-flux combinations (or wire-gas combinations) for use with automatic multi-run techniques		
3	Butt weld test for manual arc electrodes		

7.7 In general, the welding consumables are to be subject to visual examination.

7.8 Type test report

The works manufacturing the welding consumables are required to submit the type test report to CCS, which contain the following items:

(1) Test date, environmental conditions and pre-treatment of welding consumables;

(2) Grade, trade mark or brand, type and dimension of the welding consumables;

(3) Material designation, grade, mechanical properties and chemical compositions of test plates;

(4) Welding position;

(5) Welding parameters, the model of welding machines and composition of shielding gas;

(6) All test results;

(7) Welding site records.

8 Unit/batch inspection

8.1 After obtaining works approval by CCS, the manufacturer is to apply for unit/batch inspection on the welding consumables for marine use manufactured according to the approved conditions (including equipment, process, etc.).

8.2 Unit/batch inspection is as follows:

Unit/batch inspection requirements

Table 8.2

Serial No.	Name of consumables	Inspection items
1	Electrodes for manual arc welding of structural steel	(1) examination of quality certificate of wire rods (2) visual examination (3) confirmation of chemical composition of deposited metal (4) deposited metal test (5) additional deep penetration butt welding for electrodes for deep penetration welding in the downhand welding position
2	Wire-flux combinations for submerged arc automatic welding for structural steel	(1) examination of quality certificate of wire rods (2) visual examination (3) confirmation of chemical composition of deposited metal (4) deposited metal test (5) butt welding for wire-fluxes combinations for use with two-run technique
3	Wires and wire-gas combinations for manual, semi-automatic and automatic welding of structural steel	(1) examination of quality certificate of wire rods (2) visual examination (3) confirmation of chemical composition of deposited metal (4) deposited metal test (5) butt welding test for wires and wire-gas combinations for use with automatic two-run technique
4	Consumables for use in electro-slag and electro-gas vertical welding of structural steel	(1) examination of quality certificate of wire rods (2) visual examination (3) confirmation of chemical composition of deposited metal (4) butt weld test
5	Fluxes	(1) visual examination (2) examination of quality certificate of combined wires (3) deposited metal test

8.3 After satisfactory inspection of products, CCS Surveyor is to issue a certificate of marine products or endorse the manufacturer's quality certificate.

8.3.1 The quality certificate is to contain at least the purchaser, acceptance criteria, batch number, approved grade, specification, welding position, mass, quantity, chemical composition,

mechanical properties, identification with related description. The space for stamp and endorsement by CCS Surveyor is to be reserved.

8.3.2 The format of the manufacturer's quality certificate is to be approved by CCS.

8.4 Package and identification

8.4.1 All the packages of approved consumables are to be clearly identified with:

(1) Trade mark or brand;

(2) Name or mark of manufacturer;

(3) Approved grade of consumables (and combined consumables for submerged arc welding and gas-shielded welding);

(4) Groups of shielding gases adopted;

(5) Applicable welding current type and/or current polarity;

(6) Applicable welding position;

(7) Manufacturing date and batch number;

(8) Drying temperature and time;

(9) Dimension (diameter of welding core, length of electrodes, grain size of fluxes for automatic submerged arc welding).

8.4.2 The welding consumables approved by CCS may be allowed to use the following dedicated logo according to the use license of CCS product approval logo, subject to the requirements given in 3.1.7 of Chapter 3, PART ONE of China Classification Society Rules for Classification of Sea-Going Steel Ships.

Figure 8.4.2 CCS Approved Product Logo