IEC 62523

Edition 1.0 2010-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Cargo/vehicle radiographic inspection system

Instrumentation pour la radioprotection – Système radiographique d'inspection de cargaison/véhicule

IEC 62523:2010

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 62523

Edition 1.0 2010-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Cargo/vehicle radiographic inspection system

Instrumentation pour la radioprotection – Système radiographique d'inspection de cargaison/véhicule

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX S

ICS 13.280

ISBN 978-2-88912-002-4

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – CARGO/VEHICLE RADIOGRAPHIC INSPECTION SYSTEM

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62523 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/638/FDIS	45B/652/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

RADIATION PROTECTION INSTRUMENTATION – CARGO/VEHICLE RADIOGRAPHIC INSPECTION SYSTEM

1 Scope and object

This International Standard applies to radiographic inspection systems with photon radiation energy of at least 500 keV for inspection of cargo, vehicles and cargo containers.

Such inspection systems generally consist of radiation source(s), detectors, control system, image processing system, radiation safety system and other auxiliary devices/facilities.

The object of this standard is to define the tests and the relevant testing methods for determining the performance characteristics of the radiographic inspection systems.

This standard is not applicable to those cargo/vehicle inspection systems using neutron source radiography, computed tomography or backscatter technology.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 60204-1:2005, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

ISO 4948-1, *Steels – Classification – Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

ISO 9978:1992, *Radiation protection – Sealed radioactive sources – Leakage test methods*

IAEA Safety Guide No.RS-G-1.10, *Safety of Radiation Generator and Sealed Radioactive Sources*

IAEA Safety Guide No.TS-R-1, *Regulations for the Safe Transport of Radioactive Material*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply, as well as those given in IEC 60050-393 and IEC 60050-394.

3.1
transmission image
a projection image created by X-rays or gamma-rays passing through an inspected object, based on the difference of their attenuation by the inspected object

3.2
cargo/vehicle radiographic inspection system (inspection system)
a system that makes use of X-ray or gamma-ray sources and radiation detectors to obtain transmission images of cargo or vehicles

3.3
X-ray inspection system
an inspection system that uses accelerator(s) or generator(s) to produce bremsstrahlung radiation as the source of X-ray for obtaining images

3.4
gamma-ray inspection system
an inspection system that uses radionuclide(s) as the source of gamma-ray for obtaining images

3.5
controlled area
a controlled area is any area in which specific protection measures and safety provisions are or could be required for:

a) controlling normal exposures or preventing the spread of contamination during normal working conditions; and

b) preventing or limiting the extent of potential exposures

[IAEA No. 115]

3.6
supervised area
any area not designated as a controlled area but for which occupational exposure conditions are kept under review even though specific protective measures and safety provisions are not normally needed

[IAEA No. 115]

3.7
system boundary
the outer boundary of the supervised area

3.8
total absorber
any object through which the transmitted radiation is reduced to a level at which it is not possible to distinguish from the background

3.9
steel penetration
the maximum thickness of steel (stated in mm), through which the X-rays or gamma-rays from the inspection system can be measured and distinguished from the background

3.10
wire detection
the minimum cross-section size of a wire, e.g., the diameter of a wire stated in mm, which can be measured and distinguished from the background

3.11
contrast sensitivity
the ability to distinguish a small difference of measurements in an area from a surrounding uniform background

3.12
spatial resolution
the ability to distinguish a pair of small object as separate entities

3.13
multiple energy system
an inspection system operating with two or more different spectra of radiation energy, and being capable of distinguishing different materials

3.14
material discrimination capability
certain capability of an inspection system to discriminate different classes of materials

3.15
scanning speed
the speed of the inspected object moving relative to the inspection system, or vice versa

3.16
inspection dimension
the outer dimension of the largest object which could be scanned and inspected by an inspection system

3.17
isodose contour
a perimeter around the inspection system on which all points receive equal amounts of radiation dose from the operational radiation source

3.18
ambient dose equivalent rate
the ratio of dHx(10) by dt, where dHx(10) is the increment of ambient dose equivalent in the time interval dt

$$\dot{H}x(10) = \frac{\mathrm{d}Hx(10)}{\mathrm{d}t}$$

The SI unit of ambient dose equivalent rate is the sievert per second ($Sv \cdot s^{-1}$). Units of ambient dose equivalent rate are any quotient of the sievert or its decimal multiples or submultiples by a suitable unit of time (e.g., $mSv \cdot h^{-1}$).

[IEC 60846-2009]

NOTE For a gamma-ray isotope, ambient dose equivalent rate assumes an instantaneous rate. For a pulsed x-ray–generating device, ambient dose equivalent rate is given by the time-weighted average over a full pulse cycle.

4 General characteristics of cargo/vehicle radiographic inspection system

4.1 General

The inspection systems are designed to create an image of the inspected object for an operator to detect, locate, and identify contraband hidden in cargo and/or vehicles. Such a system is generally composed of a radiation source(s), detectors, a mechanical and control system, an image processing system, a radiation safety system to protect the operators and the public against radiation, and other auxiliary devices/facilities.

The manufacturer shall state power requirements and the warm-up or set-up time of the system.

4.2 Emergency stop devices

Inspection systems shall be equipped with emergency stop devices such as emergency buttons, so that the radiation beam can be automatically shut off or the radioactive source can be automatically retracted into its shielding assembly whenever any of these devices is activated. Once any emergency stop device has been activated, the system shall not be able to restart the radiation beam automatically. Manual operation, such as inserting a key on the operator control panel and turning it to the “ON” position, is required to enable the restart of the radiation beam.

Emergency stop devices shall be installed at several locations including, but not limited to the operator control panel and in relatively close proximity to the radiation source and the detectors.

The emergency stop devices shall work in a fail-safe mode. If an emergency stop device fails, the radiation beam shall be shut off, and a failure status shall be indicated on the control panel.

For a gamma-ray system, the radioactive source shutter shall be automatically closed or the source shall be automatically retracted into its shielding assembly, in case of power failure.

4.3 Software

The system shall be able to process and display, save, backup and restore the digital radiographic images of the inspected objects and other relevant inspection data, such as container numbers, inspection date and cargo contents.

4.4 Markings

Markings shall be readable and permanently attached, including at least:

- manufacturer name;
- model number;
- unique serial number;
- function designation for control, switches, adjustments;
- radiation source and energy;
- ionizing radiation warning symbol;
- other safety warnings.

4.5 Ambient dose equivalent rate isodose contour

The manufacturer should provide an isodose contour of the ambient dose equivalent rate around the source when the inspection system is operating.

This isodose contour is provided for reference purposes only. It may change substantially based upon the motion of the system and the object placed in the beam.

4.6 Radioactive sources

Radioactive sources shall be properly shielded and protected from unauthorized access. The transportation and labelling of the radioactive sources shall comply with national and/or international requirements (e.g., IAEA No.TS-R-1 and IAEA No.RS-G-1.10).

Provisions should be made for routine leak testing of the radioactive sources, in accordance with ISO 9978:1992 in order to minimize the radiation exposure to the operator.

4.7 Safety interlocks

Safety interlocks shall be installed to prevent people from being accidentally exposed. The radiation beam can only be turned on after all the safety interlocks are in the “ON” position. If the status of any interlocks changes during operation, the radiation beam shall be terminated or shuttered. The safety interlocks shall be designed to work in fail safe mode.

The safety interlocks shall provide an interface to link additional safety devices.

4.8 Status indicators

Status indicators shall be installed to provide audible and visual warning signals to warn people of the danger of radiation exposure. These warning signals shall be started at least 5 s before the beam is turned on and remain on during the scan until the radiation beam is turned off. The configuration of status indicators shall comply with local regulations.

Ionizing radiation warning symbols or placards shall be placed along the boundary of the controlled area and the supervised area.

4.9 Monitoring system

A video monitoring system shall be provided for the operator to observe the controlled area and the supervised area.

5 Inspection system classification

The inspection system should be classified as:

- X-ray inspection system: an inspection system that uses an X-ray source for obtaining images;
- Gamma-ray inspection system: an inspection system that uses a gamma-ray source for obtaining images.

6 General test procedures

6.1 Nature of tests

Except where otherwise specified, the tests and test methods of Clauses 9, 10 and 11 in this standard shall be considered as type tests. All the tests and test methods in this standard may be considered acceptance tests based upon agreement between the user and the manufacturer.

6.2 Reference conditions and standard test conditions

Except where otherwise specified, tests shall be carried out under the standard test conditions shown in the third column of Table 1. For tests performed outside the standard test

conditions, the values of temperature, pressure and relative humidity shall be stated and the appropriate corrections, if any, made to give the response under reference conditions. All tests in Clauses 7 and 8 shall be performed with the same values of these operating parameters. The values of any corrections should be stated. Reference conditions are given in the second column of Table 1.

The values in Table 1 are intended for tests performed in temperate climates. In other climates, the actual values for the test shall be stated. Similarly atmospheric pressure lower than 70 kPa may be permitted at higher altitudes.

Table 1 – Reference conditions and standard test conditions

Environment conditions	Reference conditions	Standard test conditions
Environment temperature	20 °C	15 °C to 35 °C
Relative humidity	65 %	50 % to 75 %
Atmospheric pressure	101,3 kPa	70 kPa to 106,6 kPa
Background radiation doserate	Ambient dose equivalent rate 0,1 $\mu Sv \cdot h^{-1}$	Ambient dose equivalent rate less than 0,25 $\mu Sv \cdot h^{-1}$
Ambient electromagnetic field	Negligible	Less than the lowest value that causes interference
Ambient magnetic induction	Negligible	Less than twice the value of the induction due to earth's magnetic field

6.3 Other conditions of the test

The plates, wires and sheets mentioned in Clause 7 of this standard should be fabricated with C45 steel as defined in ISO 4948-1 or equivalent. The steel test pieces may be painted or plated to eliminate dirty rust surfaces. All dimensions are specified prior to painting or plating. Wires used in this standard are round wires.

The scanning speed, source intensity, source energy, source pulse rate for systems with a linear accelerator source shall be stated for each test in Clauses 7 and 8.

7 Imaging performance tests

7.1 Steel penetration

7.1.1 Requirements

The manufacturer shall state the steel penetration expressed in millimeters as determined in 7.1.2.

7.1.2 Test method

a) The test apparatus is shown in Figure 1. The length of each side of the rectangular steel plate shall not be less than 500 mm. The bottom of the plate shall be parallel to the ground.

b) The minimum length of each side of the section of the rectangular total absorber perpendicular to the radiation beam shall not be less than 200 mm as shown in Figure 1.

c) The total absorber should be placed at the centre of the steel plate. The minimum distance between the total absorber and the nearest edge of the steel plate should not be less than 50 mm.

d) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

e) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

f) If the total absorber is discernible in the scanned image, then increase the thickness of the steel plate and scan the apparatus again until the total absorber is not discernible in the scanned image. The increment of the thickness shall be 10 mm.

g) The steel penetration is the sum of the thicknesses of the steel plates, behind which the total absorber is discernible in the scanned image.

h) Additional measurements in other positions can be made based upon agreement between the user and the manufacturer.

i) A statistical method with multiple tests for the determination of steel penetration may be used based upon agreement between the user and the manufacturer.

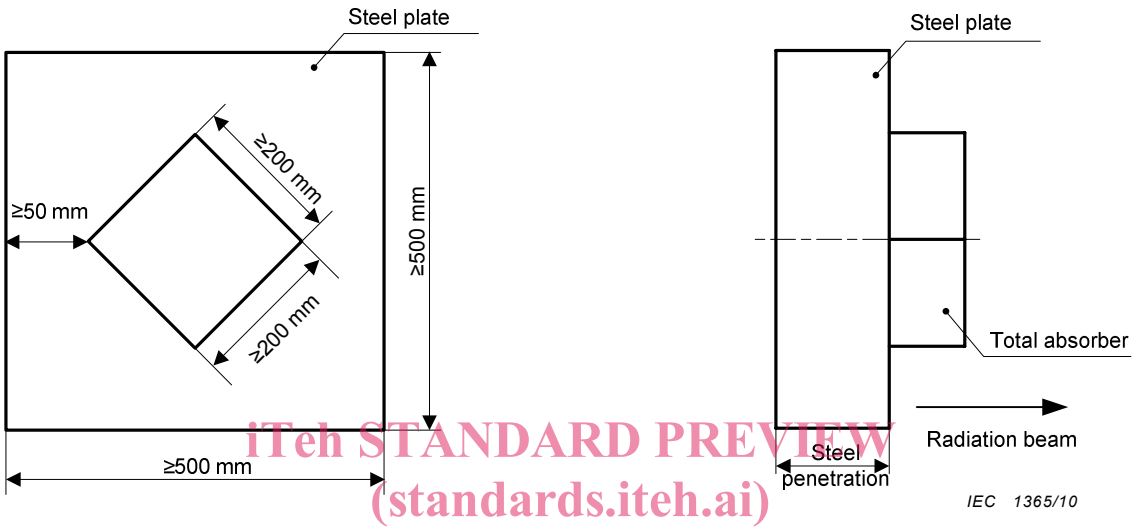

Figure 1 – Steel penetration testing apparatus

7.2 Wire detection

7.2.1 Requirements

The manufacturer shall state the wire detection expressed in millimeters as determined in 7.2.2.

7.2.2 Test method

a) One steel wire, or more such wires of different diameters shall be placed in air or behind a steel plate with a thickness of 100 mm. The test apparatus with steel plate is shown in Figure 2. The length of each side of the rectangular steel plate shall not be less than 500 mm. The bottom of the plate shall be parallel to the ground. Note that a low atomic number material plate may be used to support the wire(s) when they are placed in air.

b) The distance between the ends of a steel wire and the nearest edge of the steel plate, if any, shall not be less than 50 mm. The distance between any two wires shall not be less than 50 mm. All the wires used shall be at least 100 mm long and oriented at 45º to the sides of the plate.

c) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

d) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

e) If all the steel wires are discernible in the scanned image, then decrease the diameters of the steel wires and scan the apparatus again until at least one of the steel wires is not discernible in the scanned image. The decrement of the diameter shall be 0,1 mm.

f) The wire detection is the diameter of the thinnest wire, which is discernible in the scanned image.

g) Additional measurements with other thicknesses of the steel plate may be made based upon agreement between the user and the manufacturer.

h) Additional measurements at other positions may be made based upon agreement between the user and the manufacturer.

i) Wires may also be shaped as circles or sinusoids based upon agreement between the user and the manufacturer.

j) A statistical method with multiple tests for the determination of wire detection may be used based upon agreement between the user and the manufacturer.

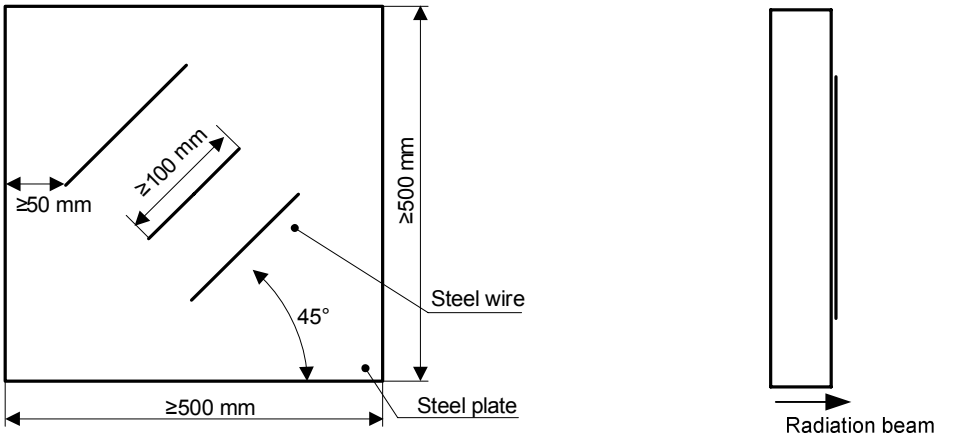

Figure 2 – Wire detection testing apparatus

7.3 Contrast sensitivity

7.3.1 Requirements

The manufacturer shall state the contrast sensitivity expressed in percentage as determined in 7.3.2.

7.3.2 Test method

a) One rectangular steel sheet, or more such sheets of different thicknesses, shall be placed behind a steel plate with a thickness of 100 mm. The test apparatus with steel plate is shown in Figure 3. The length of each side of the rectangular steel plate shall be at least 500 mm. The bottom of the plate shall be parallel to the ground.

b) The length of the each side of the sheet(s) shall not be less than 100 mm and oriented at 45° to the side of the plate as shown in Figure 3.

c) The minimum distance between a steel sheet and the nearest edge of the steel plate shall not be less than 50 mm. The minimum distance between any two steel sheets shall not be less than 50 mm.

d) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

e) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

f) If all the steel sheets are discernible in the scanned image, then decrease the thickness of the steel sheet and scan the apparatus again until at least one of the steel sheets is not discernible in the scanned image. The decrement of the thickness shall be 0,1 mm.

g) The contrast sensitivity is the ratio (expressed as a percentage) of the thickness of the thinnest steel sheet, which is discernible behind the steel plate of a specified thickness, to the thickness of the steel plate.

h) Additional measurements with steel plate of other thicknesses may be made based upon agreement between the user and the manufacturer.