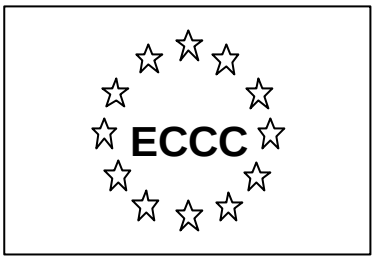

ECCC RECOMMENDATIONS - VOLUME 2 Part IIb [Issue 2]

TERMS AND TERMINOLOGY FOR WELD CREEP TESTING

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ECCC RECOMMENDATIONS - VOLUME 2 Part IIb [Issue 2]

TERMS AND TERMINOLOGY FOR WELD CREEP TESTING

PREPARED BY ECCC-WG1

Mr P Auerkari	VTT, Finland	
Prof B Buchmayr	Technische Univ. Graz, Austria	
Dr C K Bullough	ALSTOM Power ETC, UK	
Ir C Coussement	Belgian Welding Institute, Belgium	
Dr-Ing J Granacher	IfW TU Darmstadt, Germany	
Dr S R Holdsworth	ALSTOM Power, UK	[Convenor]
Mr S Holmström	VTT, Finland	
Dr-Ing A Klenk	MPA Stuttgart, Germany	
Dipl-Ing H König	ALSTOM Power, Germany	
Dr-Ing G Merckling	Istituto Scientifico Breda, Italy	
Dr P F Morris	Corus, UK	
Mr J Orr	Corus, UK	
Mr J H Rantala	JRC IAM Petten	
Dr D G Robertson	ERA Technology Ltd, UK	[Secretary]
Prof R Sandström	SIMR, Sweden	

EDITED BY: P F MORRIS

APPROVED **On behalf of ECCC** **DATE** 4/01/01

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ABSTRACT

ECCC Recommendations – Volume 2 Part IIb presents terms and terminology, with explanations where required, related to the constituent parts of a weldment (or welded joint), the location of testpieces within/across the weldment, and the results of stress rupture tests carried out on weldments. Terms and terminology are also included for specially prepared weld metal (which does not form a weldment) and on material which has been heat treated to simulate a specific part of a weldment (eg coarse grained heat affected zone).

ECCC Recommendations Volume 2 Part IIb user feedback is encouraged and should be sent to:

Dr P F Morris [Document Controller]
Corus UK
Swinden Technology Centre
Moorgate
Rotherham S60 3AR, UK.
Tel: +44 1709 825327
Fax: +44 1709 825337
E-mail: peter.f.morris@corusgroup.com

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Contents of Volume 2 Part IIb

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1. FOREWORD

Volume 2 Part IIb presents terms and terminology with explanations, related to the constituent parts of a weldment (or welded joint), how testpieces are located within/across the weldment and results from stress rupture tests carried out. When other than stress rupture testing is carried out special reporting is advised.

It is also recognised that valid tests may be carried out on specially prepared weld metal, i.e. not forming a weldment and on material heat treated to simulate a specific part of a weldment, e.g. coarse grained heat affected zone. Terms and terminology relating to such conditions are included.

2. WELD DESCRIPTORS

The following terms and terminology are used to describe the various items and regions which constitute a weldment or welded joint. For the terms and terminology relating to the manufacture and processes used to produce weldments, reference should be made to Volume 2 Part IIa produced by WG3.1.

The following terms and symbols (see also Section 5) are used to describe the various components of a weld deposit/weldment/simulated part of a weldment.

(i) Weld Metal - all metal melted during the making of a weld and retained in the weld [WM].

(ii) Deposited Metal - filler metal after it becomes part of the weldment (see (v)) [D].

(iii) Buttered Layer(s) - surface variation(s) deriving from metal deposited on one or more surfaces to provide metallurgically compatible weld metal for the subsequent completion of the weld [BL].

(iv) Weld Pad - a specially deposited amount of weld metal on a substrate e.g. on a piece of plate, but which does not form a weldment [WP].

(v) Weldment - a joint between two items of parent metal (see (vi)). A weldment incorporates the deposited weld metal and the heat affected zones [W].

(vi) Parent Material(s) - metal(s) to be joined by welding. These may be of the same material and same product form or may be of two different materials e.g. dissimilar metals. Parent metal(s) is (are) designated thus:

PM - one material, from a single batch joined by welding [PM].

PM1 and PM2 - dissimilar metals or same material from different batches/products joined by welding [PM1] [PM2].

Thus a weldment is described schematically:

PM(1)	HAZ^{+}_{1}	WM	HAZ (1 or 2)	PM (1 or 2)

$^{+}$see 3.2.3

A weldment is made up of weld metal and HAZ regions between two parent materials [see for descriptions on page 2, items (i), (v), (vi) and (viii)]. With regard to the parent materials several situations exist depending on the degree of similarity or not of the parent materials. The following terminology and terms are considered to apply*

Terminology	**Term**
Homogeneous - when both parent materials are from the same batch.	PM
Similar* - when both parent materials are of the same steel grade but from different batches.	PM1(a)/PM1(b)
Dissimilar* - when parent materials are from different steel grades, which may be of the same steel type, e.g. ferritic to ferritic or different steel types, e.g. ferritic to austenitic.	PM1 PM2

* Similar terminology exists in EN 288-1 but is considered not sufficiently comprehensive for the requirements of ECCC.

(vii) Fusion Line(s) - the nominal boundary between parent material and weld metal. [FL].

(viii) Heat Affected Zone(s) - those parts of the parent material affected/ changed metallurgically by the heat of welding but not melted. Particular areas within the heat affected zone (HAZ) are identified by pre-codes, e.g. CG, FG and IC (see Section 3.2.3). [XXHAZ].

(ix) Simulated HAZ Material – metal with uniform metallurgical structure, produced either by heat treatment or by thermo-mechanical treatment, to simulate a particular zone of a weldment e.g. the coarse grained HAZ region [$XXHAZ_{sim}$]. Post weld heat treatment and multi pass welding may be simulated as well - see Table 4 of Volume 3 Part II.

Peak temperature - Maximum temperature during the simulation treatment

Cooling time $t_{8/5}$ – time to cool between 800 °C and 500 °C during cooling in the simulation treatment.

In case of multi pass HAZ simulation a second peak temperature and cooling time $t_{8/5}$ can be defined.

3. TESTPIECE AND LOCATION PARAMETERS

3.1 Weld Metal/Weld Pad (see 2(i) and 2(iv))

For testpiece(s) from a weld metal, a weld metal pad, (see 2(i) and 2(iv)) or simulated heat treatment (2(ix)), the terminology used for the description of testpieces for parent material apply, and is as given in the main text of Volume 2 Part I.

Unless very small, testpieces from all weld metal (2(i) and (iv)) will be orientated in the parallel direction with respect to the weld axis. Therefore the critical reference values are:

a) k = Depth below weld surface in sector containing last weld bead (see 3.2.1 and 3.2.2) - see Figs. 1 and 2.
b) d_o = Diameter of gauge/parallel length of the testpiece.

3.2 Weldment

For testpieces from weldments (see 2(v)) several additional factors have to be taken into account which include:

(i) Direction of testpiece with respect to weld axes
(ii) Location of testpiece with respect to thickness of weld
(iii) Metallurgical zones incorporated and position of these in the testpiece.

Examples of the reference values required to describe testpiece locations are given in Fig. 1. (Taken from EN876: 1995). The dimension L_S in Fig. 1 is derived from EN895, where it is described as "maximum width of the weld after machining". In the case of EN895 it means the maximum weld width within a flat/rectangular section testpiece. For a circular section testpiece, the weld width within the section will not be constant, and probably not a critical factor in the context of weld creep testing. However, terms adopted in Fig. 2 are recommended, i.e.;

L_s = maximum weld width in the section sampled - see 3.1(a).

L_s' = weld width at centreline of testpiece.

3.2.1 Weld Axes

The weld axes relate to the direction of the weld between the two items of parent material. Terminology from BS7448 Part 2. 1997 could be used as follows - see Fig. 2.

N = Normal to weld direction
P = Parallel to weld direction
Q = Weld thickness direction*

*See below for relationship to t_Q (= weld thickness).

The additional term relative to those in 3.1 (Fig. 1) becomes for cross weld testpiece location description.

t_Q = Total weld thickness (see Fig. 2).

Unless stated otherwise, and appropriate written/diagrammatic description given, $t_{Q1} = t_{Q2}$ in Fig.2 and the testpiece axis lies parallel to the surface.

For other cases, e.g. when the testpiece axis is set perpendicular to one or other of the fusion lines, a full description (preferably with diagrams) shall be given so that the angle of the testpiece axis in relation to direction 'N' (Fig. 2) and other relevant dimensions, e.g. location of FL in testpiece gauge length, weld depth (k) at the point where FL and testpiece axis coincide etc.

3.2.2 Depth Location

In a weldment of thickness for example $\geq$ 20 mm, the testpiece(s) could be taken from one (or more) of several depths below L_S. Therefore there is a requirement for a term, designated "k" in Fig. 2, to describe the position. Thus:

k = distance between L_S and axis of the cross-weld testpiece.

3.2.3 Weld Zones in Testpiece

A testpiece located normal to the weld direction (N), as in Fig. 2, will contain weld metal, heat affected zones and one or more parent materials.

The number of weld beads in the testpiece cross section should be estimated to give a measure of relative representation between weldment and testpiece [n_w].

The various heat affected zones recognised are:-

Coarse Grained HAZ	[CGHAZ]
Fine Grained HAZ	[FGHAZ]
Intercritical HAZ	[ICHAZ]

For austenitic and also single phase ferritic stainless steels, only the CGHAZ will occur because of the absence of phase transformations.

However, for austenitic steels, any additional features within the HAZ which are considered to be of metallurgical significance, e.g. precipitate free zone, should be described and located with respect to a fusion line. [Report].

For a full description of the constitutive parts of the gauge length of cross weld testpieces, the presence and extent of the various parts of the weldment need to be recognised and assigned.

The convention chosen is to designate each metallurgical part of the weldment and parent material(s) which appear in the gauge length, (L_c) of the testpiece as 'L' with an appropriate subscript as follows:

- parent material(s) [L_{PM1} and/or L_{PM2}]
- buttered layer(s) [L_{BL1} and/or L_{BL2}]
- weld metal [L_{WM}]
- HAZ regions [L_{HAZ1} and/or L_{HAZ2}]
- number and which of fusion boundaries included [FL1 and/or FL2]

Figs. 3.1 and 3.2 show schematic representation for one and two fusion boundary situations within L_c, where above designations are represented.

4. WELDMENT TEST RESULTS

4.1 Results from Stress Rupture Test

It is assumed that most of the test(s) carried out on weld testpieces, located/manufactured/described as per 3.1 and 3.2, will be stress to rupture tests. If other tests are carried out, special reporting is required (i.e. written details) [Report exception].

Therefore results from individual tests should be recorded using the existing terms in Volume 2 Part I - Section 3.3.1 (i) - (ii) and appropriate selections from Section 4.5. Additional results will include:-

(i) fracture location. [e.g. within/at XXHAZ, WM, FL, (FL1 or FL2)]

(ii) fracture mechanism - after visual or metallographic examination e.g. SEM [Written report].

4.2 Assessed Results

Assessed results will include:-

(i) Rupture strength of weldment at given temperature and duration ($R_{u(w)/t/T}$)

(ii) Weld strength factor at temperature T for duration t relative to that of parent material (WSF)

$$WSF(t/T) = \frac{R_{u(w)/t/T}}{R_{u/t/T}^{+}}$$

(iii) Weld strength reduction factor at temperature T for duration t relative to that of parent material (SRF)

$$SRF(t/T) = \frac{R_{u/t/T}^{+} - R_{u(w)/t/T}}{R_{u/t/T}^{+}}$$

(iv) Weld time factor for given stress, σ, and temperature T relative to that of parent material (WTF)

$$WTF(\sigma/T) = \frac{t_{u(w)/\sigma/T}}{t_{u/\sigma/T}^{+}}$$

(v) Weld time reduction factor for given stress, σ, and temperature T relative to that of parent material (TRF)

$$TRF(\sigma/T) = \frac{t_{u/\sigma/t}^{+} - t_{u(w)/\sigma/T}}{t_{u/\sigma/T}^{+}}$$

$^{+}$ For dissimilar welds [see 2(vi)] the parent material referenced should be reported.

For simulated HAZ material, strength values need to be fully qualified in terms of HAZ zone simulated, e.g. coarse grained.

5. LIST OF TERMS — SYMBOL

5.1 Weld Descriptors (see Section 2)

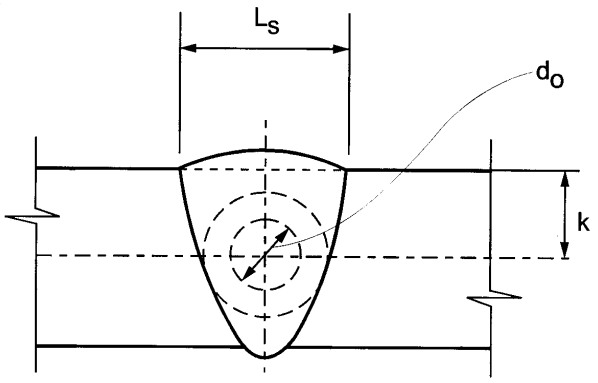
(i)	Weld Metal	WM
(ii)	Deposited Metal	D
(iii)	Buttered Layer	BL
(iv)	Weld Pad	WP
(v)	Weldment	W
(vi)	Parent Material	PM
(vii)	Fusion Line	FL
(viii)	Heat Affected Zone (see also 3.2.3)	XXHAZ
(ix)	Simulated Heat Affected Zone	$XXHAZ_{sim}$
	Peak temperature during HAZ-simulation treatment	T_{peak}
	Cooling time between 800 °C and 500 °C	$t_{8/5}$

5.2 Testpiece and Location Parameters (Section 3)

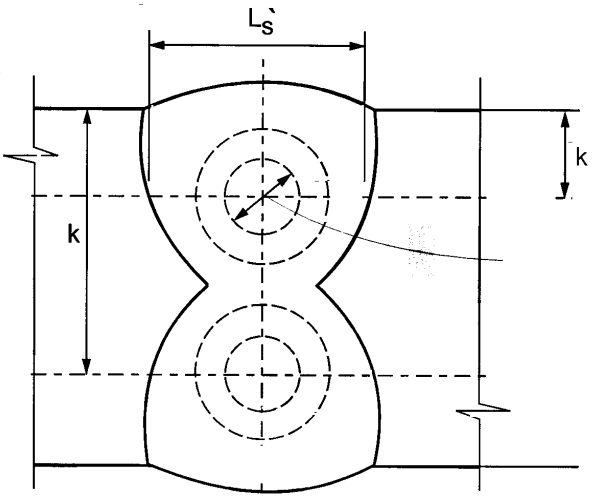
(i)	Maximum (surface) weld width (see Figs. 1 and 2).	L_s
(ii)	Weld width at centreline of testpiece.	L_s^l
(iii)	Depth of testpiece axis, below weld surface, i.e. $L_s \rightarrow L_s^l$	k
(iv)	Total weld thickness (Special note : weldment assumed to be symmetrical in terms of thickness unless otherwise indicated).	t_q
(v)	Testpiece aligned normal to weld direction.	N
(vi)	Testpiece axis aligned parallel to weld direction.	P
(vii)	Testpiece axis not aligned to weld direction, e.g. perpendicular to a fusion line.	Supply Drawing

		SYMBOL
5.3	**Metallurgical Zones in Weld and Testpiece (Section 3.2.3)**	
(i)	Component parts of HAZ.	
	• coarse grained	CGHAZ
	• fine grained	FGHAZ
	• intercritical	ICHAZ
(ii)	Special metallurgical features (to be reported), e.g. precipitate free zones.	Report
(iii)	Length of parallel length (L_c) occupied by HAZ region(s)	L_{HAZ1} or L_{H1} L_{HAZ2} or L_H
(iv)	Length of parallel length (L_c) occupied by weld metal.	L_{WM}
(v)	Length of parallel length (L_c) occupied by buttered layer(s).	L_{BL1} L_{BL2}
(vi)	Length of parallel length (L_c) occupied by parent material.	L_{PM1} L_{PM2}
(vii)	Estimate of number of weld beads in section of testpiece gauge length.	n_w
5.4	**Test Results (Section 4.1)**	
5.4.1	Assume stress to rupture test - results presented as per Vol. 2 Part I.	
5.4.2	If other than stress rupture test - use special written report for results.	
5.4.3	Additional test results:	
(i)	Zone of fracture location - see 5.1 and 5.3.	Report
(ii)	Fracture mechanism and means used, e.g. optical, SEM etc. – report in writing.	Report
5.5	**Assessed Test Results (Section 4.2)**	
(i)	Stress rupture strength of weldment - at given duration and (test) temperature.	$R_{u,w/t/T}$
(ii)	Weld strength factor – ratio of weld strength to that of parent material at a given duration and temperature	WSF
(iii)	Weld strength reduction factor – reduction in strength of weldment relative to that of parent metal at given duration and temperature.	SRF
(iv)	Weld time factor – ratio of test duration of weld to that of parent material at a given stress and temperature	WTF

		SYMBOL
(v)	Time reduction factor - reduction in test duration of weldment relative to that of parent metal at given stress and temperature.	TRF
(vi)	Strength of simulated (HAZ) material.	$R_{XXHAZ/t/T}$



Test specimen from a joint welded from one side only



Test specimen from a joint welded from both sides

FIG.1 ALL WELD METAL TEST PIECE LOCATION PARAMETERS

L_S = MAXIMUM WELD WIDTH AT SURFACE
L_S = WELD WIDTH AT TEST PIECE CENTRE
d_O = GAUGE LENGTH DIAMETER OF TEST PIECE
k = DEPTH BELOW L_S OF TEST PIECE CENTRE

R4/6401

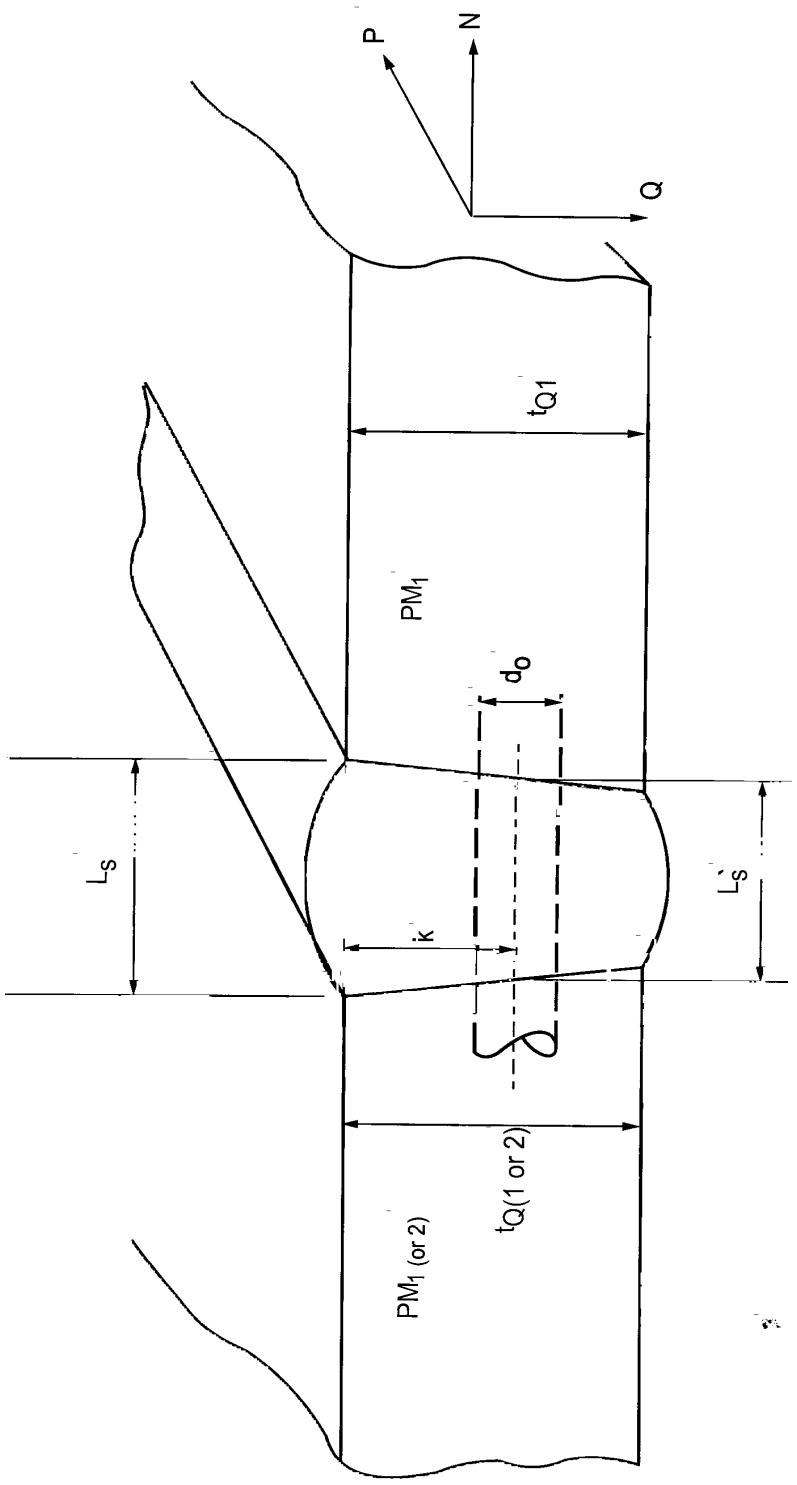


FIG.2 SCHEMATIC OF CROSS WELD TEST PIECE LOCATION PARAMETERS

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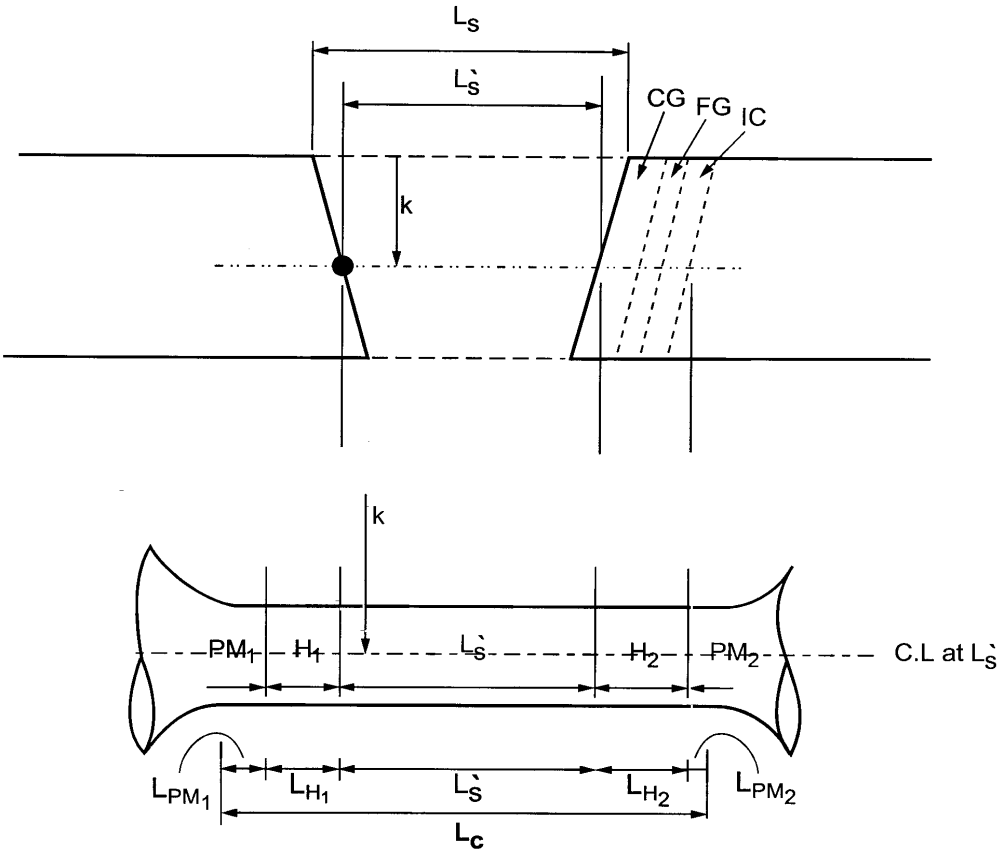


ASSUME $H_1 \approx H_2$

$$L_C = L_S' + L_{H_1} + L_{H_2} + L_{PM_1} + L_{PM_2}$$

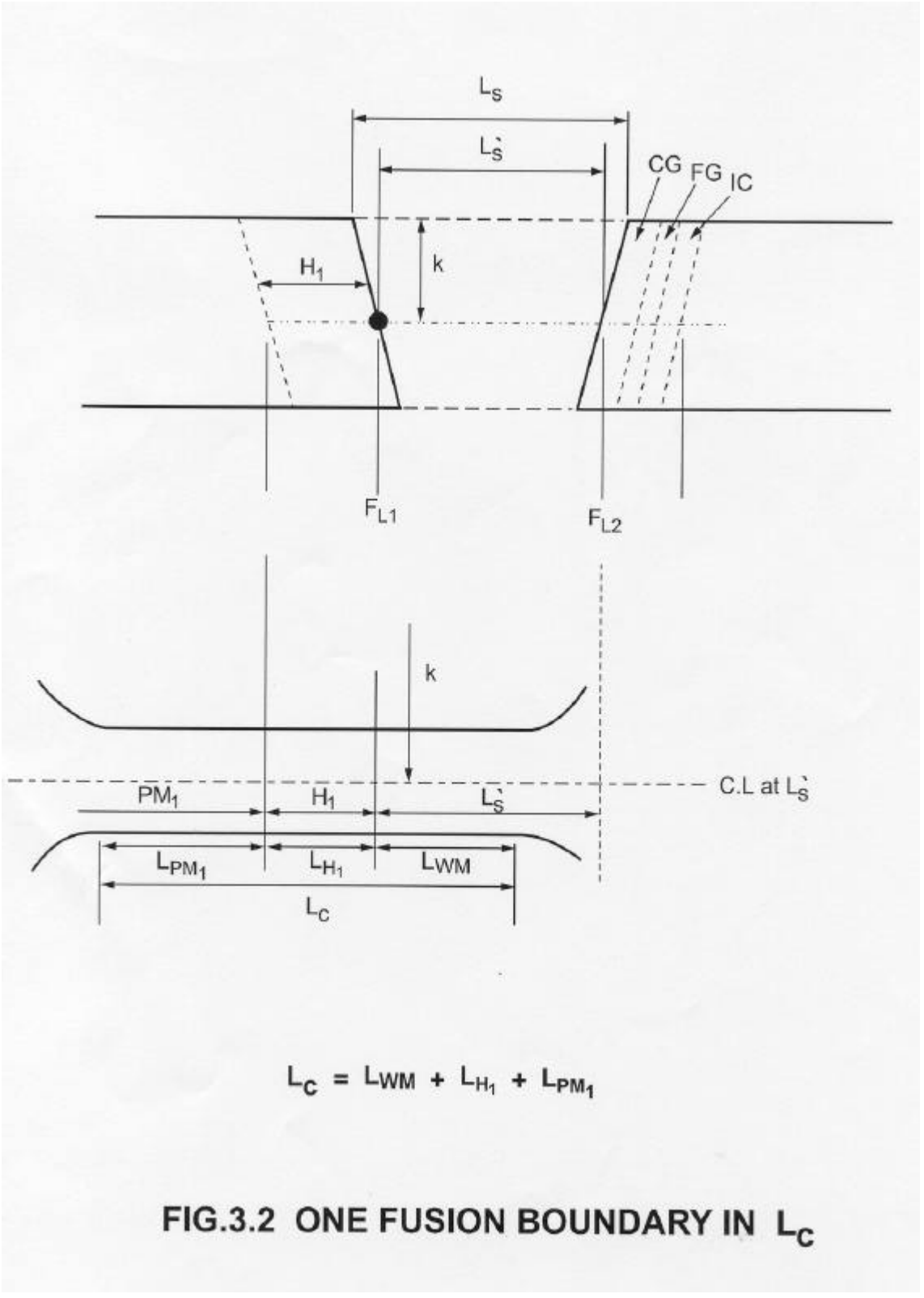
or for large H values

$$L_C = L_S' + L_{H_1} + L_{H_2}$$

(where $L_{WM} = L_S'$)

FIG.3.1 TWO FUSION BOUNDARIES WITH L_S' LOCATED CENTRALLY IN L_C

R4/6401



$$L_C = L_{WM} + L_{H_1} + L_{PM_1}$$

FIG.3.2 ONE FUSION BOUNDARY IN L_C