BRITISH STANDARD

BS EN
10250-3:2000



# Open die steel forgings for general engineering purposes —

## Part 3: Alloy special steels

The European Standard EN 10250-3:1999 has the status of a British Standard

ICS 77.140.85

# National foreword

This British Standard is the official English language version of EN 10250-3:1999. This British Standard supersedes BS 4670:1971 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/31, Wrought steels, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

**Cross-references**

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

**Summary of pages**

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 12, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 February 2000



ISBN 0 580 35393 1

**Amendments issued since publication**

| Amd. No. | Date | Comments |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 10250-3

October 1999

ICS 77.140.20; 77.140.85

English version

# Open die steel forgings for general engineering purposes - Part 3: Alloy special steels

Pièces forgées en acier pour usage général - Partie 3: Aciers spéciaux alliés

Freiformschmiedestücke aus Stahl für allgemeine Verwendung - Teil 3: Legierte Edelstähle

This European Standard was approved by CEN on 9 September 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Central Secretariat: rue de Stassart, 36 B-1050 Brussels**



Ref. No. EN 10250-3:1999 E

## Contents

**Foreword**

This European Standard has been prepared by Technical Committee ECISS/TC 28, Steel forgings, the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2000, and conflicting national standards shall be withdrawn at the latest by April 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make reference to this European Standard.

The titles of the other parts of this European Standard are:

Part 1: General requirements

Part 2: Non-alloy quality and special steels

Part 4: Stainless steels

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This part of this European Standard specifies the technical delivery requirements for open die forgings, forged bars and products pre-forged and finished in ring rolling mills, manufactured from alloy special steel and supplied in the quenched and tempered condition.

NOTE: The majority of steels listed in this part of EN 10250 are identical to steels specified in EN 10083-1 and more extensive information on hardenability and technological properties is given in that European Standard.

General information on technical delivery conditions is given in EN 10021.

## 2 Normative references

This part of EN 10250 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 10021 General technical delivery requirements for iron and steel products

EN 10083-1 Quenched and tempered steels – Part 1: Technical delivery conditions for special steels

EN 10250-1 Open die steel forgings for general engineering purposes – Part 1: General requirements

## 3 Chemical composition

### 3.1 Cast analysis

The chemical composition of the steel shall be determined by cast analysis and shall conform to the analysis given in Table 1 (see A.7 and A.8, of EN 10250-1).

Measures should be taken to prevent the addition from the scrap, or other material used in the manufacture of the steels, of such elements which affect the hardenability, mechanical properties and applicability of the steel.

### 3.2 Product analysis

The product analysis shall not deviate from the specified cast analysis (see Table 1) by more than the values specified in Table 2 (see 9.2 of EN 10250-1).

## 4 Heat treatment

Heat treatment details are not given in Table A1 for guidance.

## 5 Mechanical properties

The mechanical properties determined on test pieces selected, prepared and tested in accordance with clauses 11 and 12 of EN 10250-1 shall conform to the property requirements given in Table 3.

**Table 1: Steel grades and chemical composition[1)]**

| Steel designation | | C | Si | Mn | P max | S max | Cr | Mo | Ni | V |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Number | % | % | % | % | % | % | % | % | % |
| 38Cr2 | 1.7003 | 0,35 to 0,42 | ≤ 0,40 | 0,50 to 0,80 | 0,035 | 0,035 | 0,40 to 0,60 | - | - | - |
| 46Cr2 | 1.7006 | 0,42 to 0,50 | ≤ 0,40 | 0,50 to 0,80 | 0,035 | 0,035 | 0,40 to 0,60 | - | - | - |
| 34Cr4 | 1.7033 | 0,30 to 0,37 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | - | - | - |
| 37Cr4 | 1.7034 | 0,34 to 0,41 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | - | - | - |
| 41Cr4 | 1.7035 | 0,38 to 0,45 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | - | - | - |
| 25CrMo4 | 1.7218 | 0,22 to 0,29 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,30 | - | - |
| 34CrMo4 | 1.7220 | 0,30 to 0,37 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,30 | - | - |
| 42CrMo4 | 1.7225 | 0,38 to 0,45 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,30 | - | - |
| 50CrMo4 | 1.7228 | 0,46 to 0,54 | ≤ 0,40 | 0,50 to 0,80 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,30 | - | - |
| 36CrNiMo4 | 1.6511 | 0,32 to 0,40 | ≤ 0,40 | 0,50 to 0,80 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,30 | 0,90 to 1,20 | - |
| 34CrNiMo6 | 1.6582 | 0,30 to 0,38 | ≤ 0,40 | 0,50 to 0,80 | 0,035 | 0,035 | 1,30 to 1,70 | 0,15 to 0,30 | 1,30 to 1,70 | - |
| 30CrNiMo8 | 1.6580 | 0,26 to 0,34 | ≤ 0,40 | 0,30 to 0,60 | 0,035 | 0,035 | 1,80 to 2,20 | 0,30 to 0,50 | 1,80 to 2,20 | - |
| 36NiCrMo16 | 1.6773 | 0,32 to 0,39 | ≤ 0,40 | 0,30 to 0,60 | 0,030 | 0,025 | 1,60 to 2,00 | 0,25 to 0,45 | 3,60 to 4,10 | - |

**Table 1: Steel grades and chemical composition (concluded)**

| Steel designation | | C | Si | Mn | P Max | S Max | Cr | Mo | Ni | V |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Number | % | % | % | % | % | % | % | % | % |
| 51CrV4 | 1.8159 | 0,47 to 0,55 | ≤ 0,40 | 0,70 to 1,10 | 0,035 | 0,035 | 0,90 to 1,20 | - | - | 0,10 to 0,25 |
| 33NiCrMoV14-5 | 1.6956 | 0,28 to 0,38 | ≤ 0,40 | 0,15 to 0,40 | 0,035 | 0,035 | 1,00 to 1,70 | 0,30 to 0,60 | 2,90 to 3,80 | 0,08 to 0,25 |
| 40CrMoV13-9 | 1.8523 | 0,35 to 0,45 | 0,15 to 0,40 | 0,40 to 0,70 | 0,035 | 0,035 | 3,00 to 3,50 | 0,80 to 1,10 | - | 0,15 to 0,25 |
| 18CrMo4 | 1.7243 | 0,15 to 0,21 | ≤ 0,40 | 0,60 to 0,90 | 0,035 | 0,035 | 0,90 to 1,20 | 0,15 to 0,25 | - | - |
| 20MnMoNi4-5 | 1.6311 | 0,17 to 0,23 | ≤ 0,40 | 1,00 to 1,50 | 0,035 | 0,035 | ≤ 0,50 | 0,45 to 0,60 | 0,40 to 0,80[2)] | - |
| 30CrMoV9 | 1.7707 | 0,26 to 0,34 | ≤ 0,40 | 0,40 to 0,70 | 0,035 | 0,035 | 2,30 to 2,70 | 0,15 to 0,25 | ≤ 0,60 | 0,10 to 0,20 |
| 32CrMo12 | 1.7361 | 0,28 to 0,35 | ≤ 0,40 | 0,40 to 0,70 | 0,035 | 0,035 | 2,80 to 3,30 | 0,30 to 0,50 | ≤ 0,60 | - |
| 28NiCrMoV8-5 | 1.6932 | 0,24 to 0,32 | ≤ 0,40 | 0,15 to 0,40 | 0,035 | 0,035 | 1,00 to 1,50 | 0,35 to 0,55 | 1,80 to 2,10 | 0,05 to 0,15 |

[1)] At the option of the manufacturer the elements aluminium, titanium, vanadium and niobium may be added singly or in combination for grain control purposes. Elements not quoted in Tables 1 and 2 shall not be added intentionally to the steel without the agreement of the purchaser, except for the purpose of finishing the heat.

[2)] For greater cross-sections up to 1,00 % Ni is admissible.

**Table 2: Permissible deviations between the product analysis and the limiting values given in Table 1 for the cast analysis**

| Element | Permissible maximum content in the cast analysis % | Permissible deviation % |
|---|---|---|
| Carbon | ≤ 0,55 | ± 0,02 |
| Silicon[1)] | ≤ 0,40 | + 0,03 |
| Manganese | ≤ 1,00 | ± 0,04 |
| | > 1,00 ≤ 1,50 | ± 0,06 |
| Phosphorus | ≤ 0,035 | + 0,005 |
| Sulphur | ≤ 0,045 | + 0,005 |
| Chromium | ≤ 2,00 | ± 0,05 |
| | > 2,00 ≤ 3,50 | ± 0,12 |
| Molybdenum | ≤ 0,30 | ± 0,03 |
| | > 0,30 ≤ 1,10 | ± 0,06 |
| Nickel | ≤ 2,00 | ± 0,05 |
| | > 2,00 ≤ 4,10 | ± 0,07 |
| Vanadium | ≤ 0,25 | ± 0,02 |

[1)] For steel 40 Cr Mo V13 9, the permissible deviation is ± 0,03 %

**Table 3: Mechanical properties in the quenched and tempered condition**

| Thickness of ruling section $t_R$ | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steel designation | | ≤ 70 mm $t_R$ (longitudinal) | | | | 70 < $t_R$ ≤ 160 mm | | | | | | 160 < $t_R$ ≤ 330 mm | | | | | |
| Name | Number | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | $KV$ min J | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | |
| | | | | | | | | l[1)] | tr[1)] | l[1)] | tr[1)] | | | l[1)] | tr[1)] | l[1)] | tr[1)] |
| 38Cr2 | 1.7003 | 350 | 600 | 17 | 35 | - | - | - | - | - | - | - | - | - | - | - | - |
| 46Cr2 | 1.7006 | 400 | 650 | 15 | 35 | - | - | - | - | - | - | - | - | - | - | - | - |
| 34Cr4 | 1.7033 | 460 | 700 | 15 | 40 | - | - | - | - | - | - | - | - | - | - | - | - |
| 37Cr4 | 1.7034 | 510 | 750 | 14 | 35 | - | - | - | - | - | - | - | - | - | - | - | - |
| 41Cr4 | 1.7035 | 560 | 800 | 14 | 35 | - | - | - | - | - | - | - | - | - | - | - | - |
| 25CrMo4 | 1.7218 | 450 | 700 | 15 | 50 | 400 | 650 | 17 | 13 | 45 | 27 | 380 | 600 | 18 | 14 | 38 | 22 |
| 34CrMo4 | 1.7220 | 550 | 800 | 14 | 45 | 450 | 700 | 15 | 10 | 40 | 22 | 410 | 650 | 16 | 12 | 33 | 17 |

[1)] l = longitudinal  tr = transverse

**Table 3: Mechanical properties in the quenched and tempered condition (continued)**

| Thickness of ruling section $t_R$ | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steel designation | | $t_R \leq 160$ mm | | | | | | $160 < t_R \leq 330$ mm | | | | | | $330 < t_R \leq 660$ mm[2] | | | | | |
| Name | Number | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | |
| | | | | l[1] | tr[1] | l[1] | tr[1] | | | l[1] | tr[1] | l[1] | tr[1] | | | l[1] | tr[1] | l[1] | tr[1] |
| 42CrMo4 | 1.7225 | 500 | 750 | 14 | 10 | 30 | 16 | 460 | 700 | 15 | 11 | 27 | 14 | 390 | 600 | 16 | 12 | 22 | 12 |
| 50CrMo4 | 1.7228 | 550 | 800 | 13 | 9 | 25 | 14 | 540 | 750 | 14 | 10 | 20 | 12 | 490 | 700 | 15 | 11 | 15 | 10 |
| 36CrNiMo4 | 1.6511 | 550 | 750 | 14 | 10 | 45 | 22 | 500 | 700 | 15 | 11 | 45 | 22 | 450 | 650 | 16 | 12 | 40 | 20 |
| 34CrNiMo6 | 1.6582 | 600 | 800 | 13 | 9 | 45 | 22 | 540 | 750 | 14 | 10 | 45 | 22 | 490 | 700 | 15 | 11 | 40 | 20 |
| 30NiCrMo8 | 1.6580 | 700 | 900 | 12 | 8 | 45 | 22 | 630 | 850 | 12 | 8 | 45 | 22 | 590 | 800 | 12 | 8 | 40 | 20 |
| 36NiCrMo16 | 1.6773 | 800 | 1 000 | 11 | 8 | 45 | 22 | 800 | 1 000 | 11 | 8 | 45 | 22 | 800 | 1 000 | 11 | 8 | 45 | 22 |
| 51CrV4 | 1.8159 | 600 | 800 | 13 | 9 | 30 | 16 | - | - | - | - | - | - | - | - | - | - | - | - |

[1] l = longitudinal tr = transverse

[2] For steels 42 CrMo 4, 50 CrMo 4, 36 CrNiMo 4 these properties apply only to a $t_R \leq 500$ mm

**Table 3: Mechanical properties in the quenched and tempered condition (concluded)**

| Thickness of ruling section $t_R$ | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steel designation | | $t_R \leq 160$ mm | | | | | | $160 < t_R \leq 330$ mm | | | | | | $330 < t_R \leq 660$ mm[2] | | | | | |
| Name | Number | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | | $R_e$ min N/mm$^2$ | $R_m$ min N/mm$^2$ | $A$ min % | | $KV$ min J | |
| | | | | l[1] | tr[1] | l[1] | tr[1] | | | l[1] | tr[1] | l[1] | tr[1] | | | l[1] | tr[1] | l[1] | tr[1] |
| 33NiCrMoV14-5 | 1.6956 | 980 | 1100 | 10 | 7 | 28 | 17 | 820 | 1000 | 12 | 8 | 48 | 27 | 780 | 950 | 12 | 8 | 48 | 27 |
| 40CrMoV13-9 | 1.8523 | 660 | 850 | 15 | 15 | 35 | 35 | 660 | 850 | 15 | 15 | 35 | 35 | 660 | 850 | 15 | 15 | 35 | 35 |
| | | 720 | 900 | 15 | 15 | 32 | 32 | 720 | 900 | 15 | 15 | 32 | 32 | 720 | 900 | 15 | 15 | 32 | 32 |
| | | 780 | 950 | 14 | 14 | 30 | 30 | 780 | 950 | 14 | 14 | 30 | 30 | 780 | 950 | 14 | 14 | 30 | 30 |
| | | 840 | 1 000 | 12 | 12 | 25 | 25 | 840 | 1 000 | 12 | 12 | 25 | 25 | - | - | - | - | - | - |
| | | 890 | 1 050 | 11 | 11 | 22 | 22 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | 940 | 1 100 | 11 | 11 | 20 | 20 | - | - | - | - | - | - | - | - | - | - | - | - |
| 18CrMo4 | 1.7243 | 275 (Rp 0.2) | 485-660 | 20 | 20 | 50 | 50 | - | - | - | - | - | - | - | - | - | - | - | - |
| 20MnMoNi4-5 | 1.6311 | 420 | 580 | 17 | 14 | 39 | 24 | 390 | 550 | 17 | 14 | 39 | 24 | - | - | - | - | - | - |
| 30CrMoV9 | 1.7707 | 700 | 900 | 12 | 8 | 35 | 20 | 590 | 800 | 14 | 10 | 35 | 20 | - | - | - | - | - | - |
| 32CrMo12 | 1.7361 | 680 | 900 | 12 | 8 | 35 | 20 | 630 | 850 | 13 | 9 | 35 | 20 | 490 | 700 | 15 | 11 | 35 | 20 |
| 28NiCrMoV8-5 | 1.6932 | 630 | 800 | 14 | 10 | 45 | 25 | 590 | 750 | 15 | 11 | 40 | 21 | 590 | 750 | 15 | 11 | 40 | 21 |

[1] l = longitudinal tr = transverse

[2] For steels 42 CrMo 4, 50 CrMo 4, 36 CrNiMo 4 these properties apply only to a $t_R \leq 500$ mm

## Annex A (informative)

## Heat treatment

Heat treatment details are given in Table A.1

**Table A.1: Heat treatment conditions**

| Steel designation | | Quenching temperature[1)] | Tempering temperature |
|---|---|---|---|
| Name | Number | °C | °C |
| 38Cr2 | 1.7003 | 830 to 870 | 540 to 680 |
| 34Cr4 | 1.7033 | 830 to 870 | 540 to 680 |
| 34CrMo4 | 1.7220 | 830 to 870 | 540 to 680 |
| 46Cr2 | 1.7006 | 820 to 860 | 540 to 680 |
| 37Cr4 | 1.7034 | 825 to 865 | 540 to 680 |
| 42CrMo4 | 1.7225 | 820 to 860 | 540 to 680 |
| 50CrMo4 | 1.7228 | 820 to 860 | 540 to 680 |
| 41Cr4 | 1.7035 | 820 to 860 | 540 to 680 |
| 25CrMo4 | 1.7218 | 840 to 880 | 540 to 680 |
| 36CrNiMo4 | 1.6511 | 820 to 850 | 540 to 680 |
| 34CrNiMo6 | 1.6582 | 830 to 860 | 540 to 680 |
| 30CrNiMo8 | 1.6580 | 830 to 860 | 540 to 680 |
| 36NiCrMo16 | 1.6773 | 865 to 885 | 550 to 650 |
| 51CrV4 | 1.8159 | 820 to 860 | 540 to 680 |
| 33NiCrMoV14-5 | 1.6956 | 820 to 890 | 550 to 650 |
| 40CrMoV13-9 | 1.8523 | 920 to 970 | 550 to 720 |
| 18CrMo4 | 1.7243 | 850 to 880 | 595 to 700 |
| 20MnMoNi4-5 | 1.6311 | 870 to 940 | 630 to 680 |
| 30CrMoV9 | 1.7707 | 840 to 870 | 540 to 680 |
| 32CrMo12 | 1.7361 | 890 to 940 | 550 to 740 |
| 28NiCrMoV8-5 | 1.6932 | 830 to 870 | 550 to 850 |

[1)] Quenching from hardening may be carried out in oil, water, or water based solutions. Caution should be observed in the use of water as a quenching medium to avoid the risk of cracking the forgings.

*blank*

# BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

**Revisions**

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

**Buying standards**

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

**Information on standards**

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

**Copyright**



BSI
389 Chiswick High Road
London
W4 4AL