A ISO 14000 essentials

A.1 This section concisely describes the essential features of the ISO 14000 family.

The ISO 14000 family addresses various aspects of environmental management. The very first two standards, ISO 14001:2004 and ISO 14004:2004 deal with environmental management systems (EMS). ISO 14001:2004 provides the requirements for an EMS and ISO 14004:2004 gives general EMS guidelines.

The other standards and guidelines in the family address specific environmental aspects, including: labeling, performance evaluation, life cycle analysis, communication and auditing.

A.2 An ISO 14001:2004-based EMS

An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to:

* identify and control the environmental impact of its activities, products or services, and to

* improve its environmental performance continually, and to

* implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.

A.3 How it works

ISO 14001:2004 does not specify levels of environmental performance. If it specified levels of environmental performance, they would have to be specific to each business activity and this would require a specific EMS standard for each business. That is not the intention.

ISO has many other standards dealing with specific environmental issues. The intention of ISO 14001:2004 is to provide a framework for a holistic, strategic approach to the organization's environmental policy, plans and actions.

ISO 14001:2004 gives the generic requirements for an environmental management system. The underlying philosophy is that whatever the organization's activity, the requirements of an effective EMS are the same.

This has the effect of establishing a common reference for communicating about environmental management issues between organizations and their customers, regulators, the public and other stakeholders.

Because ISO 14001:2004 does not lay down levels of environmental performance, the standard can to be implemented by a wide variety of organizations, whatever their current level of environmental maturity. However, a commitment to compliance with applicable environmental legislation and regulations is required, along with a commitment to continual improvement – for which the EMS provides the framework.

A.4 The EMS standards

ISO 14004:2004 provides guidelines on the elements of an environmental management system and its implementation, and discusses principal issues involved.

ISO 14001:2004 specifies the requirements for such an environmental management system. Fulfilling these requirements demands objective evidence which can be audited to demonstrate that the environmental management system is operating effectively in conformity to the standard.

A.5 What can be achieved

ISO 14001:2004 is a tool that can be used to meet internal objectives:

* provide assurance to management that it is in control of the organizational processes and activities having an impact on the environment

* assure employees that they are working for an environmentally responsible organization.

ISO 14001:2004 can also be used to meet external objectives:

* provide assurance on environmental issues to external stakeholders – such as customers, the community and regulatory agencies

* comply with environmental regulations

* support the organization's claims and communication about its own environmental policies, plans and actions

* provide a framework for demonstrating conformity via suppliers' declarations of conformity, assessment of conformity by an external stakeholder - such as a business client - and for certification of conformity by an independent certification body.

B Subroutines

The first subroutine refers to the scalar source and the second one to the enthalpy source.

```
C************************************************************************
      SUBROUTINE SORSCA(S1P,S2P)
C     Source-term for scalar species
C************************************************************************
C-----------------------------------------------------------------------*
C     STAR VERSION 4.04.000
C-----------------------------------------------------------------------*
      INCLUDE 'comdb.inc'
      COMMON/USR001/INTFLG(100)
      INCLUDE 'usrdat.inc'
      DIMENSION SCALAR(50)
      EQUIVALENCE( UDAT12(001), ICTID )
      EQUIVALENCE( UDAT03(001), CON )
      EQUIVALENCE( UDAT03(002), TAU )
      EQUIVALENCE( UDAT03(009), DUDX )
      EQUIVALENCE( UDAT03(010), DVDX )
      EQUIVALENCE( UDAT03(011), DWDX )
      EQUIVALENCE( UDAT03(012), DUDY )
      EQUIVALENCE( UDAT03(013), DVDY )
      EQUIVALENCE( UDAT03(014), DWDY )
      EQUIVALENCE( UDAT03(015), DUDZ )
      EQUIVALENCE( UDAT03(016), DVDZ )
      EQUIVALENCE( UDAT03(017), DWDZ )
      EQUIVALENCE( UDAT03(019), VOLP )
      EQUIVALENCE( UDAT04(001), CP )
      EQUIVALENCE( UDAT04(002), DEN )
      EQUIVALENCE( UDAT04(003), ED )
      EQUIVALENCE( UDAT04(004), HP )
      EQUIVALENCE( UDAT04(006), P )
      EQUIVALENCE( UDAT04(008), TE )
      EQUIVALENCE( UDAT04(009), SCALAR(01) )
      EQUIVALENCE( UDAT04(059), U )
      EQUIVALENCE( UDAT04(060), V )
      EQUIVALENCE( UDAT04(061), W )
      EQUIVALENCE( UDAT04(062), VISM )
      EQUIVALENCE( UDAT04(063), VIST )
      EQUIVALENCE( UDAT04(007), T )
      EQUIVALENCE( UDAT04(067), X )
      EQUIVALENCE( UDAT04(068), Y )
      EQUIVALENCE( UDAT04(069), Z )
      EQUIVALENCE( UDAT09(001), IS )
      common/cdsudp/dsudp
C-----------------------------------------------------------------------
```

```
C
C   This subroutine enables the user to specify source terms (per unit
C   volume) for species in linearized form:
C
C      Source = S1P-S2P*SCALAR(IS), (kg/sm3)
C
C   in an arbitrary manner.
C
C   If the species is to be fixed to a given value SCI, then the
C   following may be used:
C
C      S1P=GREAT*SCI
C      S2P=GREAT,
C
C   where SCI can be a constant or an arbitrary function of the parame-
C   ters in parameter list.
C
C   ** Parameters to be returned to STAR:  S1P,S2P
C
C   dsudp is the partial derivative of mass transfer rate with respect
c   to absolute pressure. It is only used in user cavitation model.
C-----------------------------------------------------------------------
C
C    Sample coding 1: Fix the mass concentration of scalar 1 in fluid 2
C                  to a constant value SCALAR(1)=.75
C
    IF(IS.EQ.1.AND.ICTID.EQ.2) THEN
     S1P=1.6

    ENDIF
C-----------------------------------------------------------------------
C
C    Sample coding 2: Premixed combustion with eddy break-up model
C
C     COMMON / HCONST/ FM       ,  STOXD  , ACONST , BCONST
C    *             , FMRES    ,  TIMIGS , TIMIGE , IGNC
C    *             , IAIGN(10) , IGNITE  , IHOM
C     LOGICAL IHCOMB , IGNITE
C
C     DATA   GAMA , STAF , AF   , AMFU , AMOX , AMPRO , ECOMB
C    *    /1.4   , 15.0 , 15.0 , 78.0 , 32.0 , 28.97 , 4.058E+7/
C
CC--- Initialization
C     IF(ITER.EQ.1.OR.ITER.EQ.ITERS) THEN
C       IF(IP.EQ.1) THEN
C         TIMIGS = 0.250
C         TIMIGE = 0.300
CC---  1- Magnussen`s model constants
C         ACONST = 26.0
C         BCONST = 0.5
CC---  2- Set combustion mode
C         IHCOMB = .TRUE.
CC---  3- Model constants
C         IF(IHCOMB) THEN
C           STOXD = 0.232 * STAF
```

```
C          STFM  = 1.0/(1.0+STAF)
C          FM    = 1.0/(1.0+AF)
C          ALFA  = AF/(1.0+AF)
C          CFU   = 1.0 - ALFA
C          COXD  = 0.232 * AF
C          CPROD = 1.0 - CFU - COXD
C          FMRES = MAX(0.0 , FM*(1.0-COXD/STOXD))
C        ENDIF
C---   4- Ignition cells
C        IGNC = 2
C        IAIGN(1) = 9
C        IAIGN(2) = 10
C        WRITE (6,*) '****IGNITION CELLS****'
C        DO 5 I=1,IGNC
C5        WRITE (6,*) I,'-',IAIGN(I)
C       ENDIF
C     ENDIF
CC---   5- Ignition flag
C     IF(TIME.GE.TIMIGS) THEN
C       IGNITE = .TRUE.
C     ELSE
C       IGNITE = .FALSE.
C     ENDIF
C     IF(.NOT.IGNITE) RETURN
C     IF(IP.EQ.1) WRITE(6,*) '*** IGNITION ***'
C
CC---   6- Reaction rate
C     FU = SCALAR(1)
C-----------------------------------
C     ADDTAU = ACONST * DEN /TAU
C     CFU    = FU - FMRES
C     CPROD  = BCONST * (FM - FU)
C     IF(CPROD.LT.CFU) THEN
C       SU = -ADDTAU * BCONST * (MAX((FM-FU),0.0) - FU)
C       SP = ADDTAU * BCONST
C     ELSE
C       SU = ADDTAU * FMRES
C       SP = ADDTAU
C     ENDIF
CC---   7- Sparking
C     DO 10 IC=1,IGNC
C     IGC = IAIGN(IC)
C     IF(IGC.EQ.IP) THEN
C       IF(TIME.GT.TIMIGS.AND.TIME.LT.TIMIGE) THEN
C         SU = FM*(1.0-0.827*(TIME-TIMIGS)/(TIMIGE-TIMIGS))*GREAT
C         SP = GREAT
C       ENDIF
C     ENDIF
C10    CONTINUE
C     S1P = SU
C     S2P = SP
C-------------------------------------------------------------------------
      RETURN
```

```
      END
C
C*************************************************************************
      SUBROUTINE SORENT(S1P,S2P)
C     Source-term for enthalpy
C*************************************************************************
C-------------------------------------------------------------------------*
C     STAR VERSION 4.04.000
C-------------------------------------------------------------------------*
      INCLUDE 'comdb.inc'
      COMMON/USR001/INTFLG(100)
      INCLUDE 'usrdat.inc'
      DIMENSION SCALAR(50)
      EQUIVALENCE( UDAT12(001), ICTID )
      EQUIVALENCE( UDAT03(001), CON )
      EQUIVALENCE( UDAT03(019), VOLP )
      EQUIVALENCE( UDAT04(001), CP )
      EQUIVALENCE( UDAT04(002), DEN )
      EQUIVALENCE( UDAT04(003), ED )
      EQUIVALENCE( UDAT04(004), HP )
      EQUIVALENCE( UDAT04(006), P )
      EQUIVALENCE( UDAT04(008), TE )
      EQUIVALENCE( UDAT04(009), SCALAR(01) )
      EQUIVALENCE( UDAT04(059), U )
      EQUIVALENCE( UDAT04(060), V )
      EQUIVALENCE( UDAT04(061), W )
      EQUIVALENCE( UDAT04(062), VISM )
      EQUIVALENCE( UDAT04(063), VIST )
      EQUIVALENCE( UDAT04(007), T )
      EQUIVALENCE( UDAT04(067), X )
      EQUIVALENCE( UDAT04(068), Y )
      EQUIVALENCE( UDAT04(069), Z )
C-------------------------------------------------------------------------
C
C     This subroutine enables the user to specify a source term (per unit
C     volume) for enthalpy in linearized form:
C
C        Source = S1P-S2P*T, (W/m3)
C
C     in an arbitrary manner.
C
C     If temperature is to be fixed to a given value T, then the
C     following may be used:
C
C        S1P=GREAT*T
C        S2P=GREAT,
C
C     where T can be a constant or an arbitrary function of the
C     parameters in the parameter list.
C
C     ** Parameters to be returned to STAR:  S1P,S2P
C
C-------------------------------------------------------------------------
C
C     Sample coding: Fix temperature to the value of 300 K in solid
```

```
C               No 3 (IMAT=-3)
C
    IF(ICTID.EQ.2) THEN

     S1P=92794.076

    ENDIF
C-----------------------------------------------------------------------
    RETURN
    END
C
```

C German software results of smoke calculations

The following tables show all the results obtained from the combustion German software.

allgemeine Angaben zur Verbrennung

Luftüberschußfaktor	1.15		1 : 10
Ausbrandrate	95	**%**	90 :100
Umgebungsdruck	1.013	**bar**	0.8: 1.2
Umgebungstemperatur	15.	**°C**	-30 : 45
Luftfeuchtigkeit	45	**%**	0 :100
zusätzliche Wassereinspritzung	0	**$^{kg}_{Brennstoff}$ Wasser/kg**	0 : 3

Brennstoffzusammensetzung in MASSE-%

Kohlenstoffgehalt C 82.122 %

Wasserstoffgehalt H_2 13.40 %

Schwefelgehalt S 0 %

Sauerstoffgehalt O_2 4.465 %

Sticksoffgehalt N_2 0 %

Wassergehalt im Brennstoff H_2O 0 %

Aschegehalt 0 %

Ist die Summe der Komponenten größer 100%, so wird mit dieser normiert.
Bei einer Summe unter 100% wird mit Asche ergänzt.

Berechnen Zurücksetzen Ende, Abbruch

Brennstoffzusammensetzung

Bestandteil	Masse-%
Kohlenstoffgehalt C	82.122
Wasserstoffgehalt H2	13.400
Schwefelgehalt S	0.000
Sauerstoffgehalt O2	4.465
Stickstoffgehalt N2	0.000
Wassergehalt H2O	0.000
Aschegehalt ---	0.013
Einspritzwasser H2O	0.000
Luftfeuchtigkeit H2O	0.000

Umgebungsbedingungen

A. relative Luftfeuchte = 0.00 %
B. Umgebungstemperatur = 15.0 °C
C. Umgebungsruck = 1.013 bar
D. Ausbrand (Eingabe) = 95.00 %
E. Luftüberschusszahl = 1.15

Brennstoff BS

- Heizwert = 41659.2 $^{kJ}/_{kg}$
- Heizwert (sauerstoffhaltige Öle) = 41029.6 $^{kJ}/_{kg}$

Rauchgas RG

- trockenes Rauchgas/Verbrennungsluft = 0.9333 $m^3_{Rauchgas}/ m^3_{Luft}$
- Mindestsauerstoffluftbedarf = 2.2308 $m^3_{O2}/ kg_{Brennstoff}$
- theoretisher minimaler Luftbedarf = 10.6230 $m^3_{Luft}/ kg_{Brennstoff}$
- Luftbedarf zur vollständigen Verbrennung = 12.2164 $m^3_{Luft}/ kg_{Brennstoff}$
- theoretisches trockenes Rauchgas-Volumen (Lambda=1) = 9.9624 $m^3_{Rauchgas}/ kg_{Brennstoff}$
- trockenes Rauchgasvolumen = 11.5558 $m^3_{Rauchgas,trocken}/ kg_{Brennstoff}$
- feuchtes Rauchgas-Volumen = 13.0354 $m^3_{Rauchgas,feucht}/ kg_{Brennstoff}$

Volumen und Masse der Rauchgas-Bestandteile bezogen auf das Brennstoff-Masse

Bestandteil	Volumen $\frac{m^3_{Rauchgas}}{kg_{Brennstoff}}$	Masse $\frac{kg_{Rauchgas}}{kg_{Brennstoff}}$
Kohlendioxid CO2	1.4258	2.8188
Kohlenmonoxid CO	0.0963	0.1204
Schwefeldioxid SO2	0.0000	0.0000
Sauerstoff O2	0.3828	0.5470
Stickstoff N2	9.6510	12.0676
Wasser im Brenngas H2O	1.4796	1.2636
Wasser in der Luft H2O	0.0000	0.0000
Wasser Einspritzung H2O	0.0000	0.0000
===SUMME der Anteile ===	13.0354	16.8173

Volumen der RG-Bestandteile bezogen auf das Volumen des trockenen bzw. feuchten Rauchgases

Bestandteil, bezogen auf ...	Volumen, trocken	Volumen, feucht
	%	%
Kohlendioxid CO2	12.338	10.938
Kohlenmonoxid CO	0.833	0.739
Schwefeldioxid SO2	0.000	0.000
Sauerstoff O2	3.312	2.936
Stickstoff N2	83.516	74.037
Wasser im Brenngas H2O		11.350
Wasser in der Luft H2O		0.000
Wasser Einspritzung H2O		0.000
===SUMME der Anteile ===	100.000	100.000

Masse der RG-Bestandteile bezogen auf das Volumen bzw. auf die Masse des feuchten Rauchgases

Bestandteil	$\frac{\text{Masse}_{\text{Rauchgaskomponente}}}{\text{Volumen}_{\text{Rauchgas, feucht}}}$	$\frac{\text{Masse}_{\text{Rauchgaskomponente}}}{\text{Masse}_{\text{Rauchgas, feucht}}}$
	$\frac{\text{g}}{\text{m}^3}$	%

Kohlendioxid CO2	216.243	16.761
Kohlenmonoxid CO	9.237	0.716
Schwefeldioxid SO2	0.000	0.000
Sauerstoff O2	41.961	3.252
Stickstoff N2	925.753	71.757
Wasser im Brenngas H2O	96.933	7.513
Wasser in der Luft H2O	0.000	0.000
Wasser Einspritzung H2O	0.000	0.000
===SUMME der Anteile ===	Dichte = 1290.1270	100.00

ungefähre adiabate Rauchgastemperatur = 1931. °C

, oder Berechnung von Stoffwerten

für *ideales Gas* ($c_p=c_p(f)$, $v=Z*R*T/p$)

thermodynamischer Zustand

Druck .1013 MPa

Temperatur 1931. °C

spez. Enthalpie kJ/kg

spez. Entropie kJ/(kg*K)

Es können Wertepaare

- p und (t oder h oder s)
- s und (t oder h)

eingegeben werden.

Stoffwertberechnung

Ergebnisse der Berechnung

Gaszusammensetzung in Masseprozent

Argon Ar:	0.0%	Neon Ne:	0.0%	Stickstoff N2:	71.8%
Sauerstoff O2:	3.3%	Kohlenmonoxid CO:	0.7%	Kohlendioxid CO2:	16.8%
Wasser H2O:	7.5%	Schwefeldioxid SO2:	0.0%	Luft :	0.0%

- Für die IDGAS-Formulierung können kalorische Größen nicht für Stoffgemische berechnet werden, es werden die Werte für Luft ausgegeben !
- Der Realgasfaktor basiert auf dem Verfahren von REDLICH und KWONG, die kritischen Parameter werden ebenfalls massegemittelt !
- Beide Formulierungen haben verschiedene Bezugspunktefür h=0 bzw. s=0!

	IDGAS $c_p(T)$ | VDI Richtlinie 4670		
Gaskonstante	R= 0.289878	0.288779	kJ/(kg*K)
Druck	p= 0.101300	0.101300	MPa
Temperatur	t= 1931.00	1931.00	°C
spezifische Enthalpie	h= 2479.10	-1000.00	kJ/kg
spezifische Entropie	s= 3.63761	-1000.00	kJ/(kg*K)
spezifisches Volumen	v= 6.30823	-1.00000	m^3/kg
Realgasfaktor	Z= 1.00014	-1.00000	
Isentropenkoeffizient	kappa= 1.28567	-1.00000	
Schallgeschwindigkeit	a= 906.408	318.277	m/s
spezifische Wärmekapazität	c_p= 1.30460	-1.00000	kJ/(kg*K)
kinematische Zähigkeit	ny= 4.121011E-04	-1.00000	m^2/s
dynamische Zähigkeit	eta= 6.532752E-05	6.705966E-05	Pa*s
Wärmeleitfähigkeit	lambda= 0.119268	0.144267	W/(m*K)

PRANDL-Zahl	Pr= 0.714582 -1.00000

FEHLER bei der Berechnung:
Aufruf: prop_gas: -html -tab "p=.1013" "t=1931." "d04= 3.2524" "d05= 0.7160" "d06= 16.7613" "d07= 7.5139" "d08= 0.0000" "d10= 71.7564" "ma=1"

D Star-CD tunnel construction. Calculations

The following commands explain all the calculations and steps done to find the values to extrude the tunnel. The program extrusion command to be displayed is:

vcex, cells number, maxim vertex number, cset, , , local, R, θ, z

that in cylindrical coordinate system,

vcex, 50, 205387, cset, , , local, , θ , z

where 50 is the number of longitudinal cells to be extrude, 205387 is the maximum number of vertex in the model already done, θ is the angle of the sector on the plane x-y divided by the number of cells layer (50) and z is the LHC inclination divided by the number of cells layer as well. All expressed on the local coordinate system. The extrusion will build the tunnel surface from point 6 (starting point) to point 5.

The approach used to estimate the angle θ' $(\theta' = 50 \cdot \theta)$ consider some values from the database pictures showed before to compare them to the same values calculated as follow:

Three points from the tunnel arc from P6 are taken to define the arc. The points are taken directly from the 3D model imported in StarCD, so the results will be an approximation.

(x_1, y_1, z_1) = (-31147.5, 651873, -9647.29)

(x_2, y_2, z_2) = (-16232.9, 432267, -6552.47)

(x_3, y_3, z_3) = (1989.15, 282605, -4429.66)

and they are used to find an empiric radius that will help to approximate θ and z.

$(x - A)^2 + (y - B)^2 = C$ C = radius (A, B) = centre

$$A = \frac{-a}{2}$$
$$B = \frac{-b}{2}$$
$$C = \sqrt{A^2 + B^2 - C}$$

(Eq. D.1)

$$\left.\begin{aligned} x_1^2 + y_1^2 + ax_1 + by_1 + c = 0 \\ x_2^2 + y_2^2 + ax_2 + by_2 + c = 0 \\ x_3^2 + y_3^2 + ax_3 + by_3 + c = 0 \end{aligned}\right\} \rightarrow$$

(Eq. D.2)

$$\rightarrow \left\{\begin{aligned} 31147.5^2 + 651873^2 - 31147.5a + 651873b + c = 0 \\ 16232.9^2 + 432267^2 - 16232.9a + 432267b + c = 0 \\ 1989.15^2 + 282605^2 - 1989.15a + 282605b + c = 0 \end{aligned}\right\}$$

$$\left.\begin{aligned} a = -6886248.101 \\ b = -1555039.227 \\ c = -373290098411.024 \end{aligned}\right\} \rightarrow \left\{\begin{aligned} A = 3443124.051mm \\ B = 777519.613mm \\ C = 3476542.805mm \end{aligned}\right.$$

r = radius = C = 3476.54m

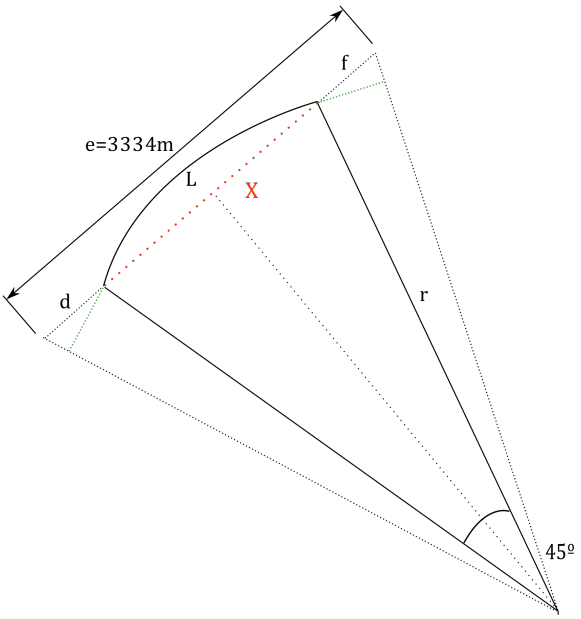

Figure D.1: schematic lines and values of sector 5-6

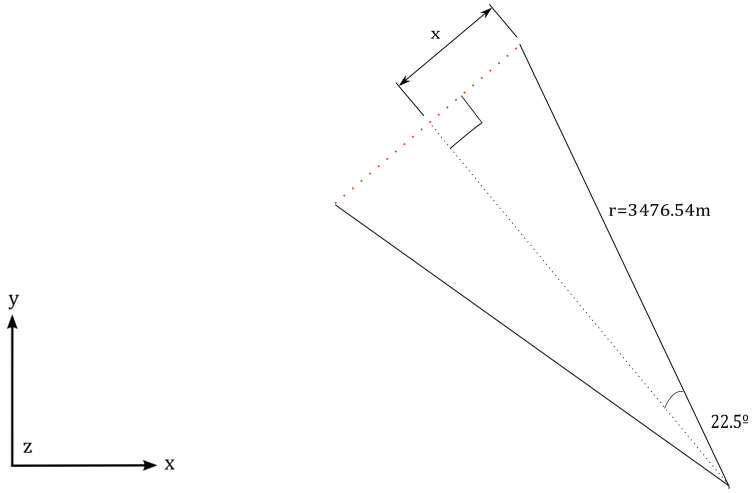

Figure D.2: schematic lines and values of the triangles geometry and the reference system

e = 3334m distance between point 5 and 6 (Fig. 6.11 on the report).

d = 238.1m projection of the green part (Fig. 6.13 on the report) which corresponds to the distance of half point 5 (Fig. 6.4 on the report).

f = 775 – 369.27 = 405.73m projection of the other green part (Fig. 6.13 on the report); 775m is the distance of half of point 6 and 369.27m is the distance in this half that already has a curvature, so is necessary to consider it into the arc operations. This value has been measured directly from the tunnel model, so is an approximation.

The LHC is composed by eight octants, corresponding to the eight sectors, but it isn't a circumference because between the different octants there are straight parts before and after the points. If these straight parts are not taken in account the angle of every sector could be considered 45° (360° / 8). Assuming the angle equal to 45° and taking the radius *r*, *X* (Fig. 6.13 on the report) can be calculated and compared with the real value *e*:

$$r \sin \frac{\theta'}{2} = x \qquad \text{(Eq. D.3)}$$

$$3476.54 \sin 22.5 = x$$
$$x = 1330.415m$$

$$X = 2 \cdot x = 2660.831$$
$$X + d + f = 3304.663m \cong 3334m = e \qquad \text{(Eq. D.4)}$$

The percentage of error:

$$E = \frac{3334 - 3304.663}{3334} \cdot 100 \cong 0.88\% \qquad \text{(Eq. D.5)}$$

some operations are calculated to estimate if the error is reasonable and the final measures to implement on the model are taken.

So the angle θ taken for the extrusion is 45° divided by 50:

$$\theta = \frac{45}{50} = 0.9$$

(Eq. D.6)

The following step is to calculate z' $\left(z' = 50 \cdot z\right)$ in the extrusion command, which corresponds to the ring inclination. The LHC was built with a small % of inclination because of the terrain geological characteristics. In figure 6.11 on the report the inclination from point 6 to point 5 (direction of extrusion) is 45.60m. But the inclination z' wanted corresponds only to the curve part, so some operations are required before its estimation:

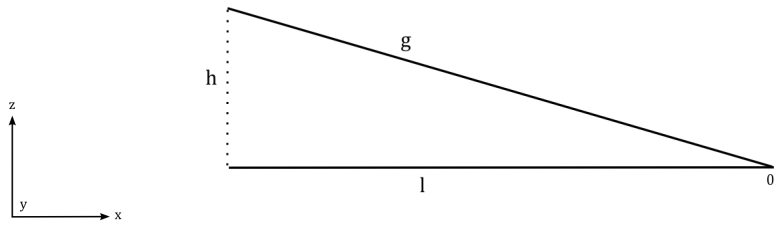

Figure D.3: schematic lines and values of geometrical triangle sector 5-6 and reference system

where g is the projection of the value e calculated before on the x-z plane, which has been considered with the same value, and h is the inclination 45.60 from figure 6.11 on the report. l has been calculated:

$$l = \sqrt{g^2 - h^2} = \sqrt{3304.977^2 - 45.60^2} = 3304.663m$$

(Eq. D.7)

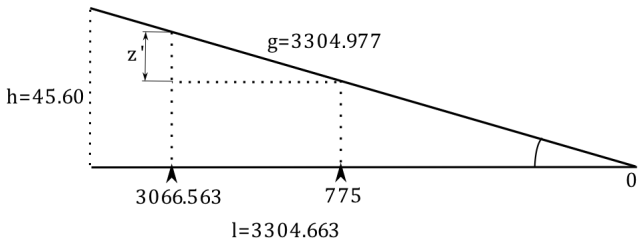

Figure D.4: schematic lines, values and geometrical triangles, sector 5-6

To calculate the z':

$$\alpha = arctg\frac{45.60}{3304.663} = 0.79055 \cong 0.8 \qquad \text{(Eq. D.8)}$$

α is the same angle in the figures above and bellow (Fig. 6.16, Fig. 6.17 on the report).

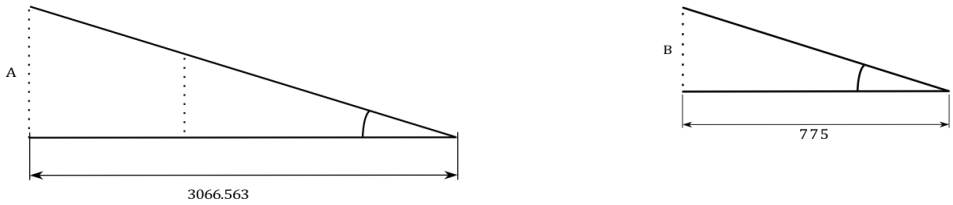

Figure D.5: schematic two sub triangles from figure 6.16 on the report

$$tg\alpha = \frac{A}{3066.563} \rightarrow A = 42.315m \quad \text{(Eq. D.9)}$$

$$tg\alpha = \frac{B}{775} \rightarrow B = 10.694m \quad \text{(Eq. D.10)}$$

$$z' = A - B = 31.62m \quad \text{(Eq. D.11)}$$

The inclination taken for the extrusion is 31.62 divided by 50 expressed in mm:

$$z = \frac{31.62 \cdot 1000}{50} = 632.4mm \quad \text{(Eq. D.12)}$$

The final command to extrude the tunnel applied is:

vcex, 50, 205387, cset, , , local, , 0.9, 632.4

The next operation is moving P5 to put it in the same reference space and make it coincident with the tunnel extruded before. The procedure consists in taking the global cartesian coordinate system and measuring the coordinates of one point from the end of the tunnel extruded; taking the same point from the tunnel part of P5 and calculate the increment of every coordinate $(\Delta x, \Delta y, \Delta z)$; then the coordinate system is changed by the cylindrical one and the same measures to calculate the rotation are repeated. The increments and the rotation are applied using two macros structures implemented into the Star-CD software.

Finally, the step after the tunnel construction is to create the magnets line inside the sector 5-6. So, keeping the tunnel on his position is necessary to estimate the values of this magnets line and the correct reference system to make it pass through the tunnel but without touching it. This estimate values has to be written in the extrusion command.

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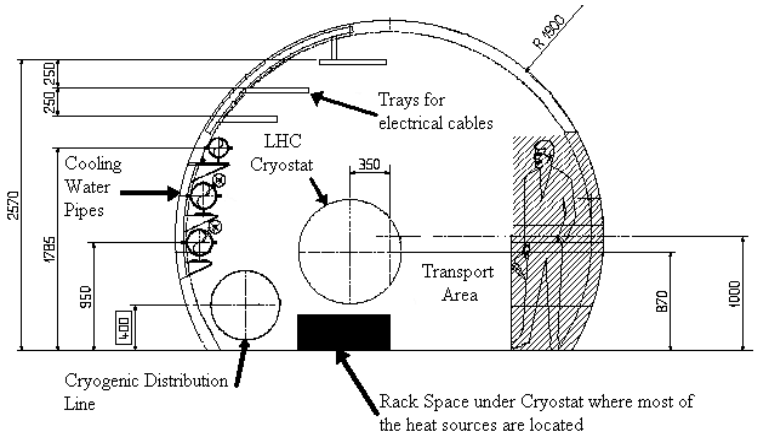

Figure D.6: tunnel components and dimensions

After some measurements, operations and approximations the extrusion was divided in some parts, the straight ones and the curve one; the curve command used is the following:

vcex, 10, 388050,cset, , , local, 4, -2.06, -1460