

## **C DADOS PARA A ESTIMATIVA DO VOLUME TOTAL VAZADO - VTV**

### **C.1 Estimativa da Vazão Efluente Através de um Furo (Q1)**

Para a estimativa das vazões efluentes (Q1) através de um furo (furo 5%D) ou trinca (furo 20%D), em cada ponto notável, durante o bombeamento, é necessário inicialmente conhecer a pressão no ponto de estudo, nesses caso adotou-se a pressão de projeto de cada trecho relativo a cada ponto. Portanto, as pressões utilizadas para cada ponto notável são as seguintes:

**Tabela C - 1: Pressão de Ponto de Interesse**

Ponto Notável	Pressão de Duto de Etanol (kgf/cm <sup>2</sup> )
No. 27 - Jardim Morumbi	89,8
No. 104 - Conjunto Habitacional Presidente Castelo Branco	70,7
No. 274 - Jardim Maria Helena	45,7
No. 290 - Bairro Jardim Nevada	35,1
No. 293 - Bairro Parque Pereira -	35,1

- As pressões obtidas para cada ponto são utilizadas como *inputs* do Programa *Effects 9.0 / TNO*, o qual tem como *outputs* os valores das vazões pertinentes. A seguir, é apresentado o cálculo para o duto de etanol, no cálculo do volume vazado, consideramos, em caso de:
  - ♦ Ruptura: vazão nominal de operação da bomba;
  - ♦ Furos 5% ou 20%: vazão máxima de operação da bomba ou a taxa de saída calculada pelo programa de simulações, limitando-se ao menor valor.
  - ♦ Com esta metodologia garantimos que a vazão de um furo (5 ou 20%) será no máximo igual ao valor da vazão da ruptura, porém nunca superior.

**Trecho 28''**

No PT 27, foi utilizada nos cálculos a pressão de projeto igual a 89,8 kgf/cm<sup>2</sup>

Vazão Nominal - VN: 2241 m<sup>3</sup>/h (maior vazão)

**PT 27 - Furo 5% - Etanol****Case description: PT 27\_5%****Model: Liquid release**

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

**Parameters**

Inputs	
Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,03556
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	1662,8
Height cylinder (m)	112
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	89,8
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

**Results**

Initial mass in vessel (kg)	1,3067E06
Mass flow rate at time t (kg/s)	
Total mass released (kg)	1,3067E06
Time needed to empty vessel (s)	1,1341E05
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	76,589
Representative release rate (kg/s)	64,203
Representative outflow duration (s)	1800
Representative pressure (bar)	70,268

**Other information**

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database

Chemical source  
Chemical source date

## PT 27 - Furo 20% - Etanol

### Case description: PT 27\_20%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

##### Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,14224
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	1662,8
Height cylinder (m)	112
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	89,8
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

##### Results

Initial mass in vessel (kg)	1,3067E06
Mass flow rate at time $t$ (kg/s)	
Total mass released (kg)	1,3067E06
Time needed to empty vessel (s)	7088,4
Filling degree at time $t$ (%)	
Height of liquid at time $t$ (m)	
Maximum mass flow rate (kg/s)	1225,4
Representative release rate (kg/s)	382,92
Representative outflow duration (s)	1800
Representative pressure (bar)	3,4642

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

No PT 104, foi utilizada nos cálculos a pressão de projeto igual a 70,7 kgf/cm<sup>2</sup>

Vazão Nominal - VN: 2241 m<sup>3</sup>/h (maior vazão)

### PT 104 - Furo 5% - Etanol

#### Case description: PT 104\_5%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

##### Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,03556
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	2070,5
Height cylinder (m)	160
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	70,7
Height leak above tank bottom (m)	41,6
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

##### Results

Initial mass in vessel (kg)	1,6271E06
Mass flow rate at time t (kg/s)	
Total mass released (kg)	1,1925E06
Time needed to empty vessel (s)	1,0167E05
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	68,971
Representative release rate (kg/s)	57,267
Representative outflow duration (s)	1800
Representative pressure (bar)	53,678

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

## PT 104 - Furo 20% - Etanol

### Case description: PT 104\_20%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

##### Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,14224
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	2070,5
Height cylinder (m)	160
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	70,7
Height leak above tank bottom (m)	41,6
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

##### Results

Initial mass in vessel (kg)	1,6271E06
Mass flow rate at time <i>t</i> (kg/s)	
Total mass released (kg)	1,1925E06
Time needed to empty vessel (s)	6354,4
Filling degree at time <i>t</i> (%)	
Height of liquid at time <i>t</i> (m)	
Maximum mass flow rate (kg/s)	1103,5
Representative release rate (kg/s)	387,67
Representative outflow duration (s)	1800
Representative pressure (bar)	2,7645

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

**Trecho 8''**

No PT 274, foi utilizada nos cálculos a pressão de projeto igual a 45,7 kgf/cm<sup>2</sup>

Vazão Nominal - VN: 170 m<sup>3</sup>/h (maior vazão)

**PT 274 - Furo 5% - Etanol****Case description: PT 274\_5%****Model: Liquid release**

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

**Parameters**

## Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,01016
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	79
Height cylinder (m)	203
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	45,7
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

## Results

Initial mass in vessel (kg)	62085
Mass flow rate at time t (kg/s)	
Total mass released (kg)	62085
Time needed to empty vessel (s)	49157
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	4,9358
Representative release rate (kg/s)	3,1909
Representative outflow duration (s)	1800
Representative pressure (bar)	14,299

**Other information**

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

## PT 274 - Furo 20% - Etanol

### Case description: PT 274\_20%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

##### Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,04064
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	79
Height cylinder (m)	203
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	45,7
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

##### Results

Initial mass in vessel (kg)	62085
Mass flow rate at time <i>t</i> (kg/s)	
Total mass released (kg)	62085
Time needed to empty vessel (s)	3072,3
Filling degree at time <i>t</i> (%)	
Height of liquid at time <i>t</i> (m)	
Maximum mass flow rate (kg/s)	78,972
Representative release rate (kg/s)	38,85
Representative outflow duration (s)	1598
Representative pressure (bar)	1,0151

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

**Trecho 12''**

No PT 290, foi utilizada nos cálculos a pressão de projeto igual a 35,1 kgf/cm<sup>2</sup>

Vazão Nominal - VN: 597 m<sup>3</sup>/h (maior vazão)

**PT 290 - Furo 5% - Etanol****Case description: PT 290\_5%****Model: Liquid release**

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

**Parameters**

## Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,01524
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	241,8
Height cylinder (m)	202
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	35,1
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

## Results

Initial mass in vessel (kg)	1,9003E05
Mass flow rate at time t (kg/s)	
Total mass released (kg)	1,9003E05
Time needed to empty vessel (s)	66773
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	10,093
Representative release rate (kg/s)	8,3666
Representative outflow duration (s)	1800
Representative pressure (bar)	22,794

**Other information**

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database



Chemical source  
Chemical source date

## PT 290 - Furo 20% - Etanol

### Case description: PT 290\_5%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

##### Inputs

Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,01524
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	241,8
Height cylinder (m)	202
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	35,1
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

##### Results

Initial mass in vessel (kg)	1,9003E05
Mass flow rate at time <i>t</i> (kg/s)	
Total mass released (kg)	1,9003E05
Time needed to empty vessel (s)	66773
Filling degree at time <i>t</i> (%)	
Height of liquid at time <i>t</i> (m)	
Maximum mass flow rate (kg/s)	10,093
Representative release rate (kg/s)	8,3666
Representative outflow duration (s)	1800
Representative pressure (bar)	22,794

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

No PT 293, foi utilizada nos cálculos a pressão de projeto igual a 35,1 kgf/cm<sup>2</sup>

Vazão Nominal - VN: 597 m<sup>3</sup>/h (maior vazão)

### PT 293 - Furo 5% - Etanol

#### Case description: PT 293\_5%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

Inputs	
Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,01524
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	271,7
Height cylinder (m)	216,5
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	35,1
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

#### Results

Initial mass in vessel (kg)	2,1353E05
Mass flow rate at time t (kg/s)	
Total mass released (kg)	2,1353E05
Time needed to empty vessel (s)	72478
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	10,204
Representative release rate (kg/s)	8,479
Representative outflow duration (s)	1800
Representative pressure (bar)	22,538

#### Other information

Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

## PT 293 - Furo 20% - Etanol

### Case description: PT 293\_20%

#### Model: Liquid release

version: 5.08 (27/01/2014)

Reference: Yellow Book, CPR-14E, 3rd edition 1997, Paragraph 2.5.4

#### Parameters

Inputs	
Chemical name	ETHANOL (DIPPR)
Use which representative step	First 20% average (flammable)
Type of vessel outflow	Release through hole in vessel
Pipeline length (m)	
Pipeline diameter (mm)	
Pipeline roughness (mm)	
Hole diameter (m)	0,06096
Hole rounding	Sharp edges
Discharge coefficient (-)	0,62
Vessel type	Vertical cylinder
Vessel volume (m3)	271,7
Height cylinder (m)	216,5
Filling degree (%)	100
Overpressure above liquid (assuming closed system) (bar)	35,1
Height leak above tank bottom (m)	0
Initial temperature in vessel (°C)	25
Type of calculation	Calculate until device is empty
Maximum release duration (s)	

#### Results

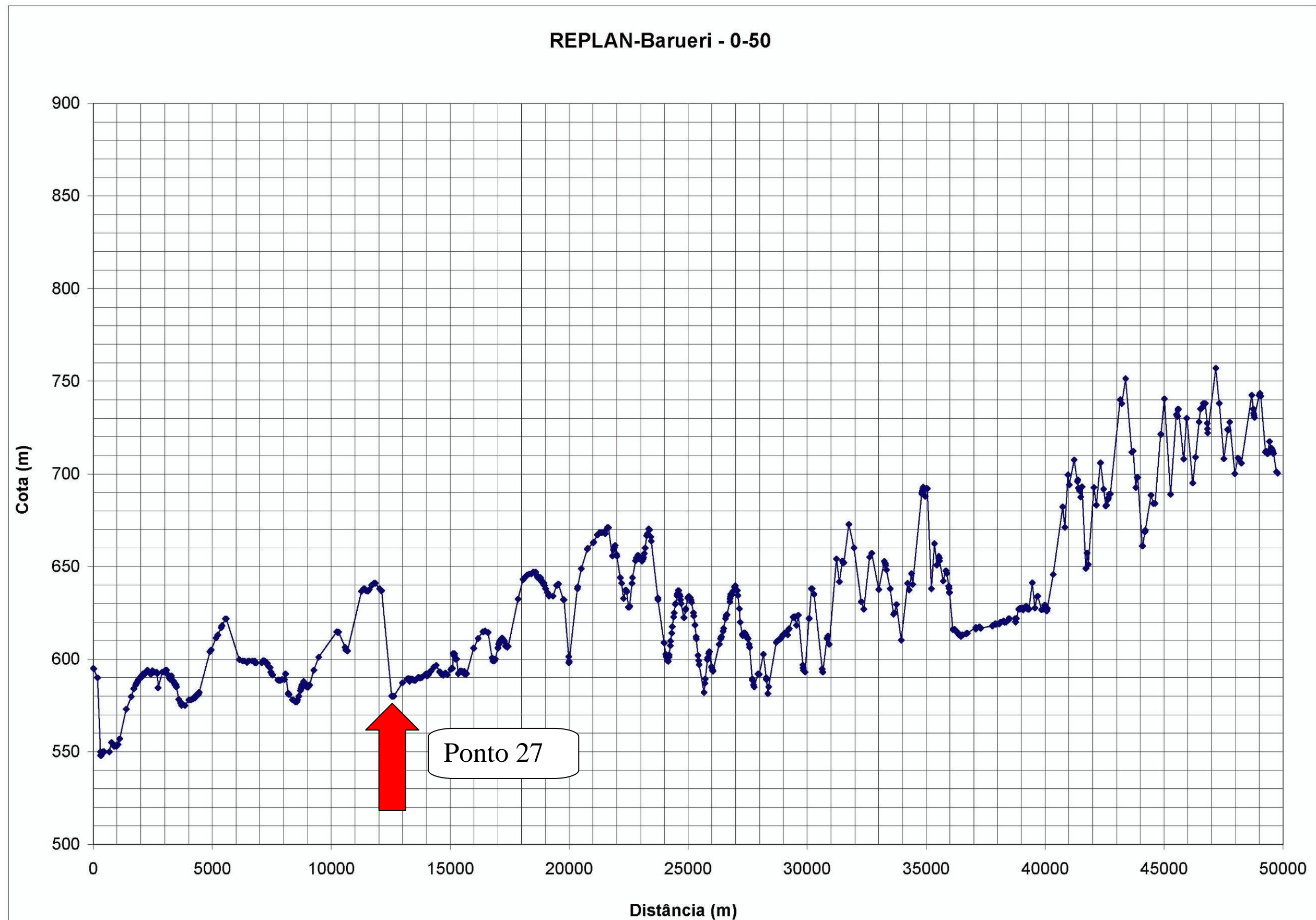
Initial mass in vessel (kg)	2,1353E05
Mass flow rate at time t (kg/s)	
Total mass released (kg)	2,1353E05
Time needed to empty vessel (s)	4529,8
Filling degree at time t (%)	
Height of liquid at time t (m)	
Maximum mass flow rate (kg/s)	163,26
Representative release rate (kg/s)	91,947
Representative outflow duration (s)	1800
Representative pressure (bar)	1,0268

#### Other information

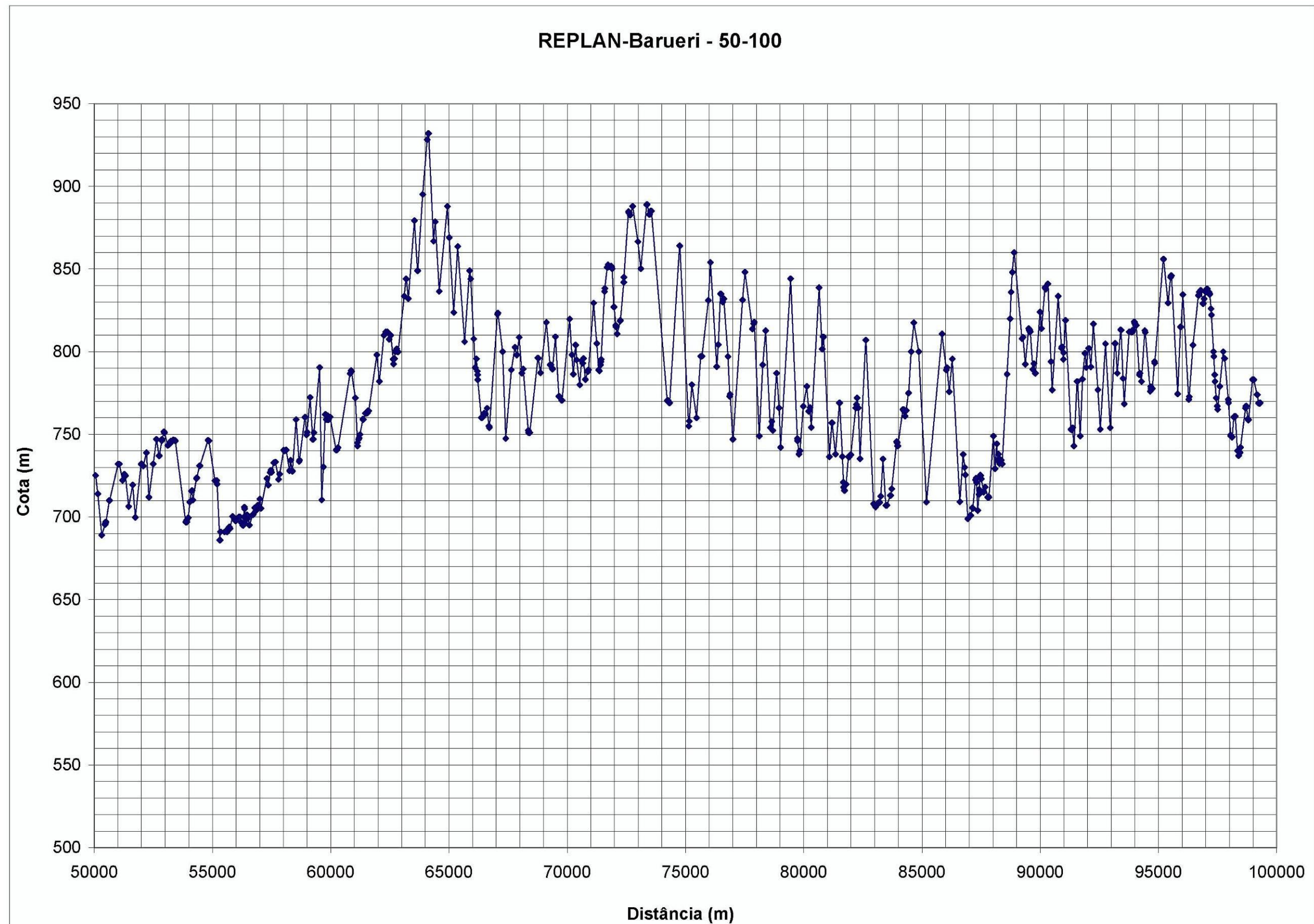
Main program	Effects 9.0.15.7718
Chemical database	DIPPR database
Chemical source	
Chemical source date	

## **C.2 Volume Máximo Escocado Sob Ação Gravitacional do Interior de Uma Tubulação Fechada em uma Extremidade (Condição sem Transferência) - V1**

Para o cálculo do volume da coluna líquida disponível ao escoamento sob ação da gravidade, foi utilizado o perfil do duto de etanol, apresentado nas Figuras C - 1 até C - 4.

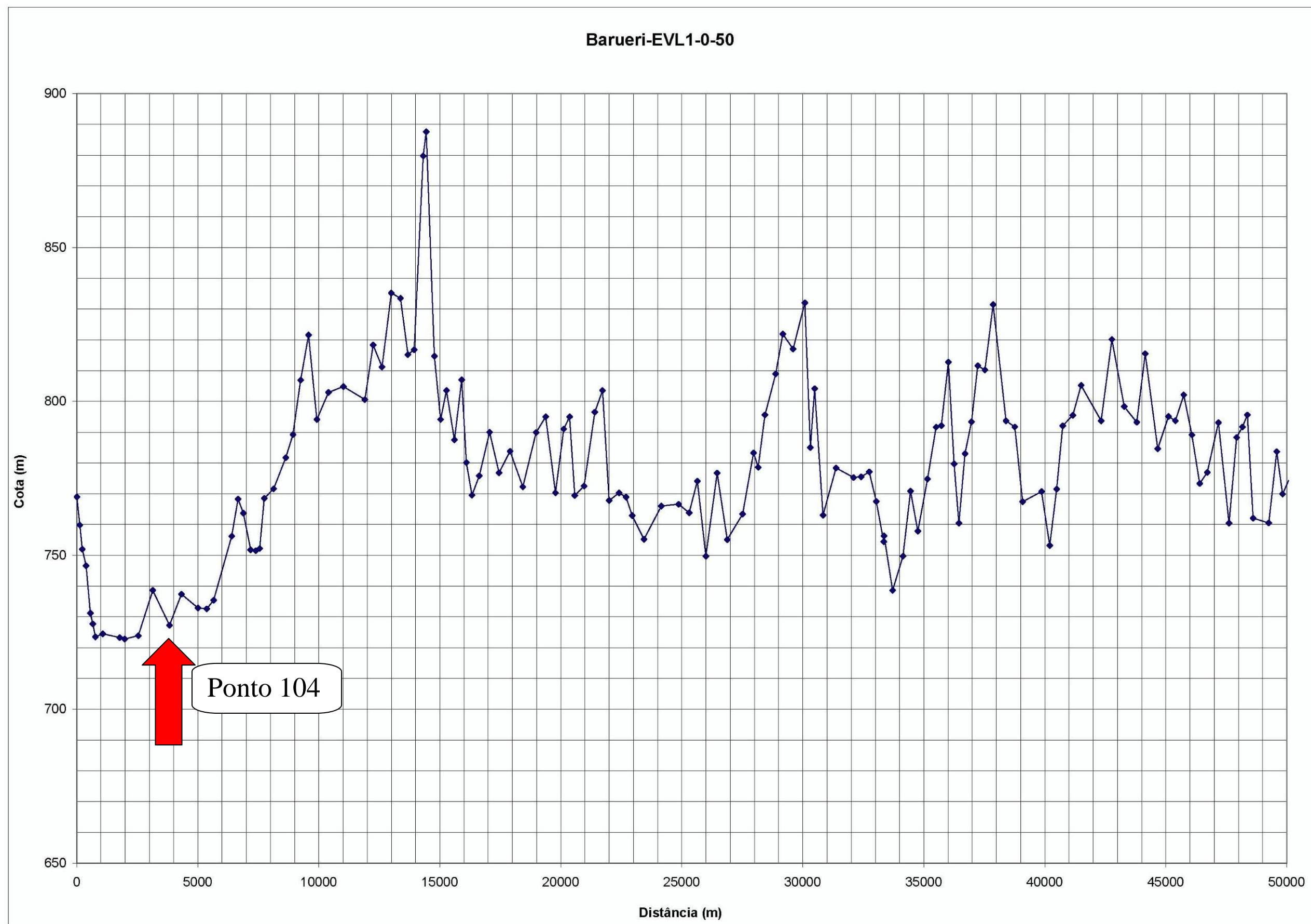


**Figura C - 1:** Perfil do duto de etanol - Trecho REPLAN - BARUERI (0-50km)

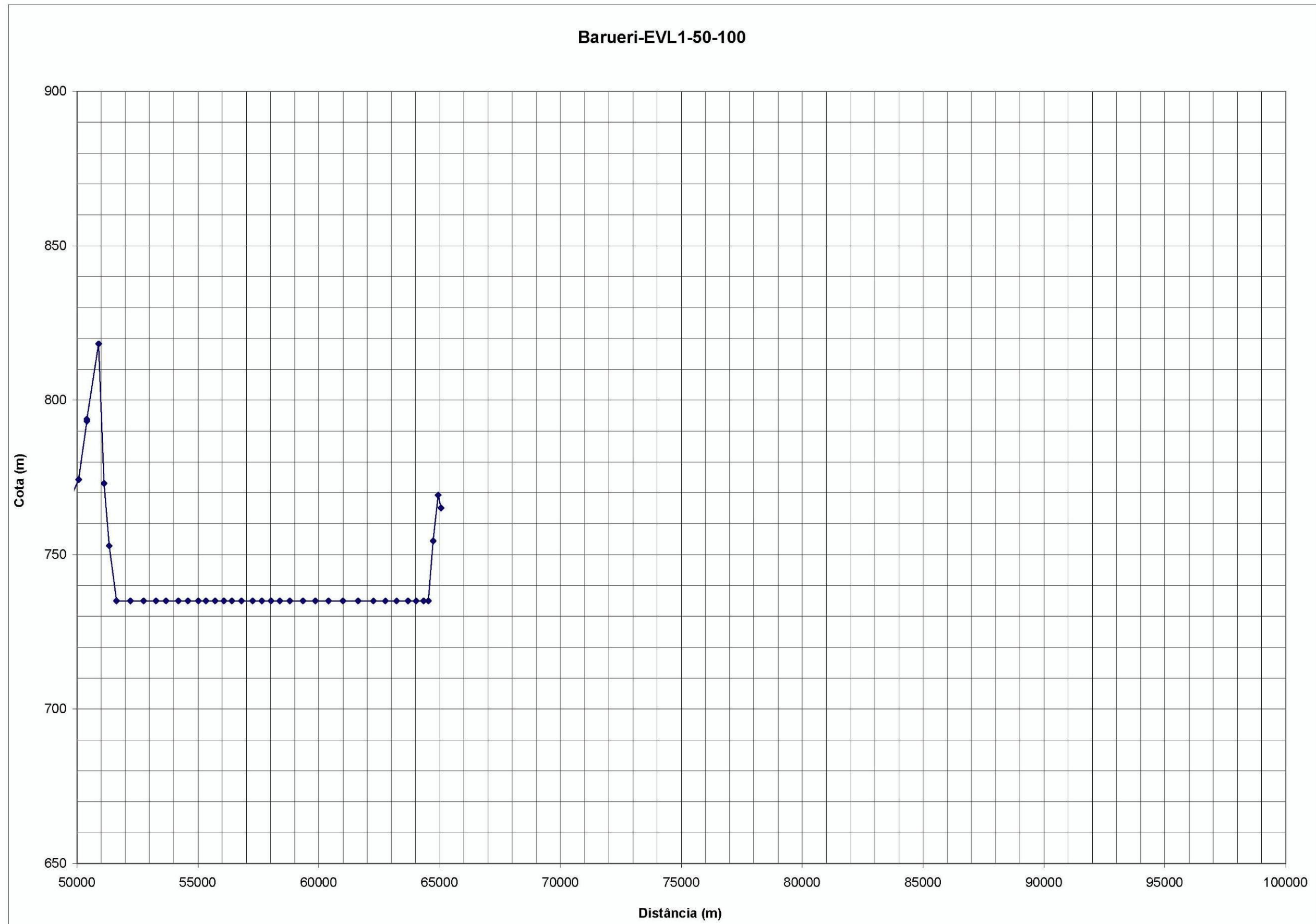


**Figura C - 2:** Perfil do duto de etanol - Trecho REPLAN - BARUERI (50-100km)



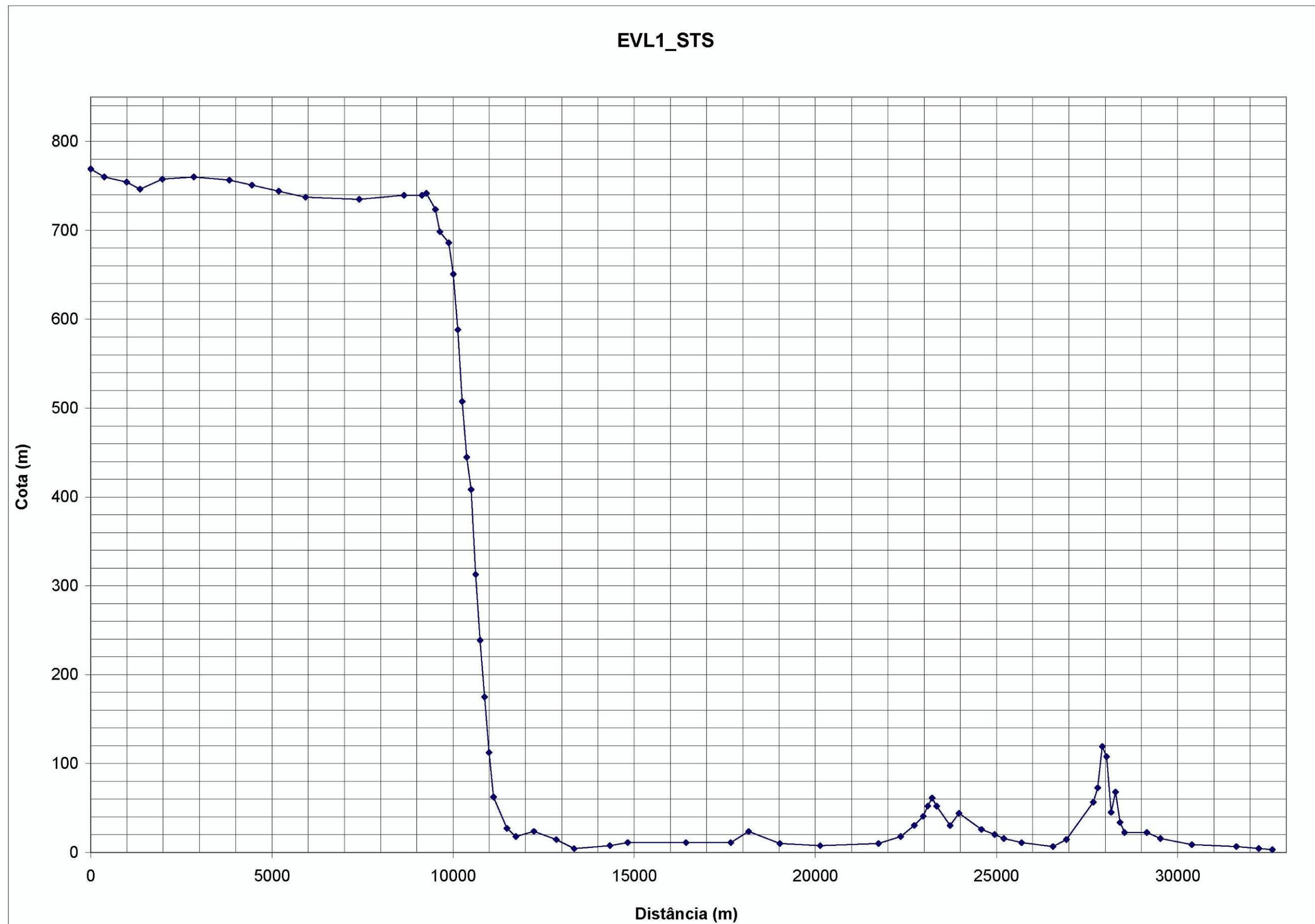


**Figura C - 3:** Perfil do duto de etanol Trecho BARUERI-EVL1 (0-50km)



**Figura C - 4:** Perfil do duto de etanol Trecho BARUERI-EVL1 (50-100km)





**Figura C - 5:** Perfil do duto de etanol Trecho EVL1-SANTOS

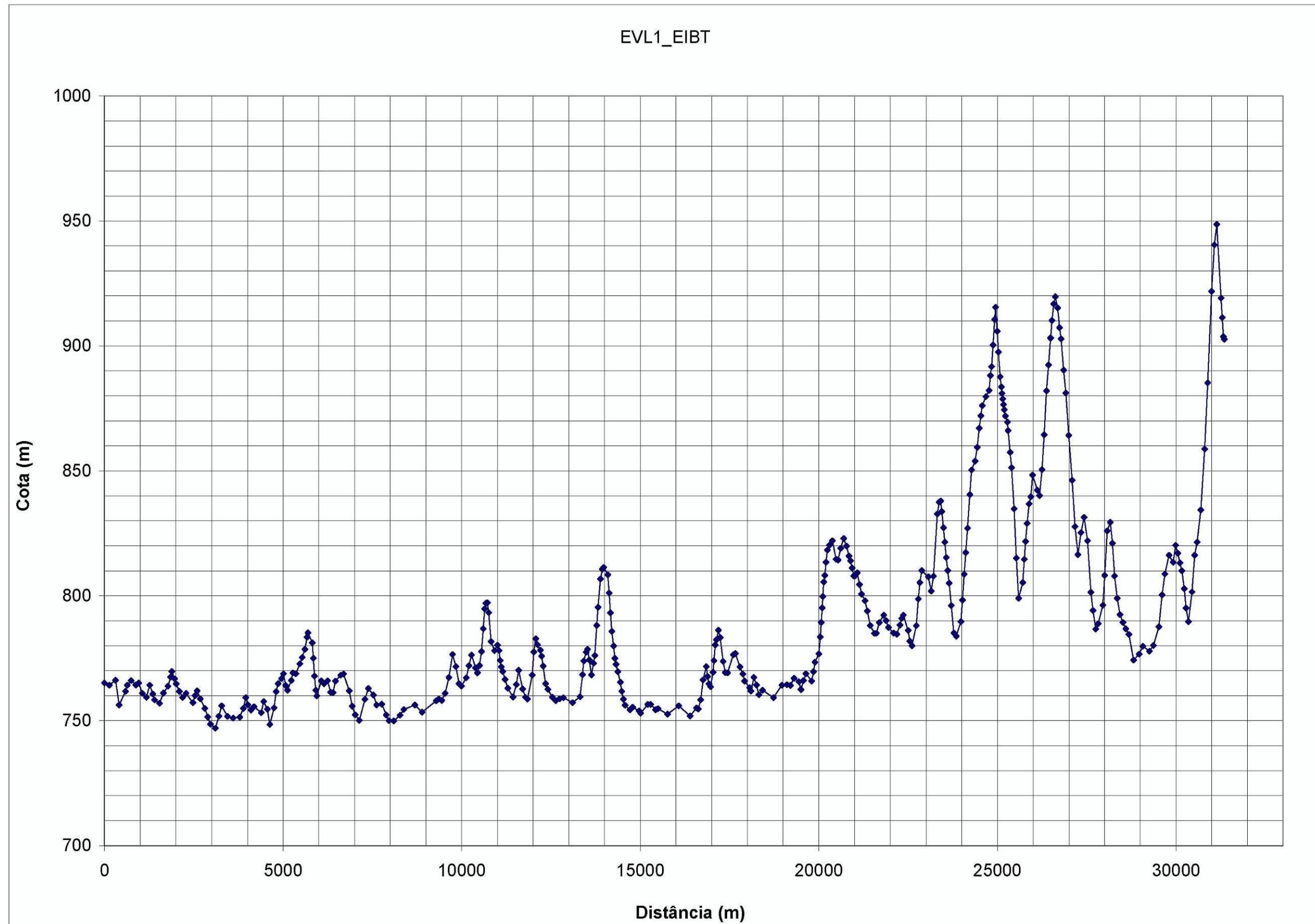
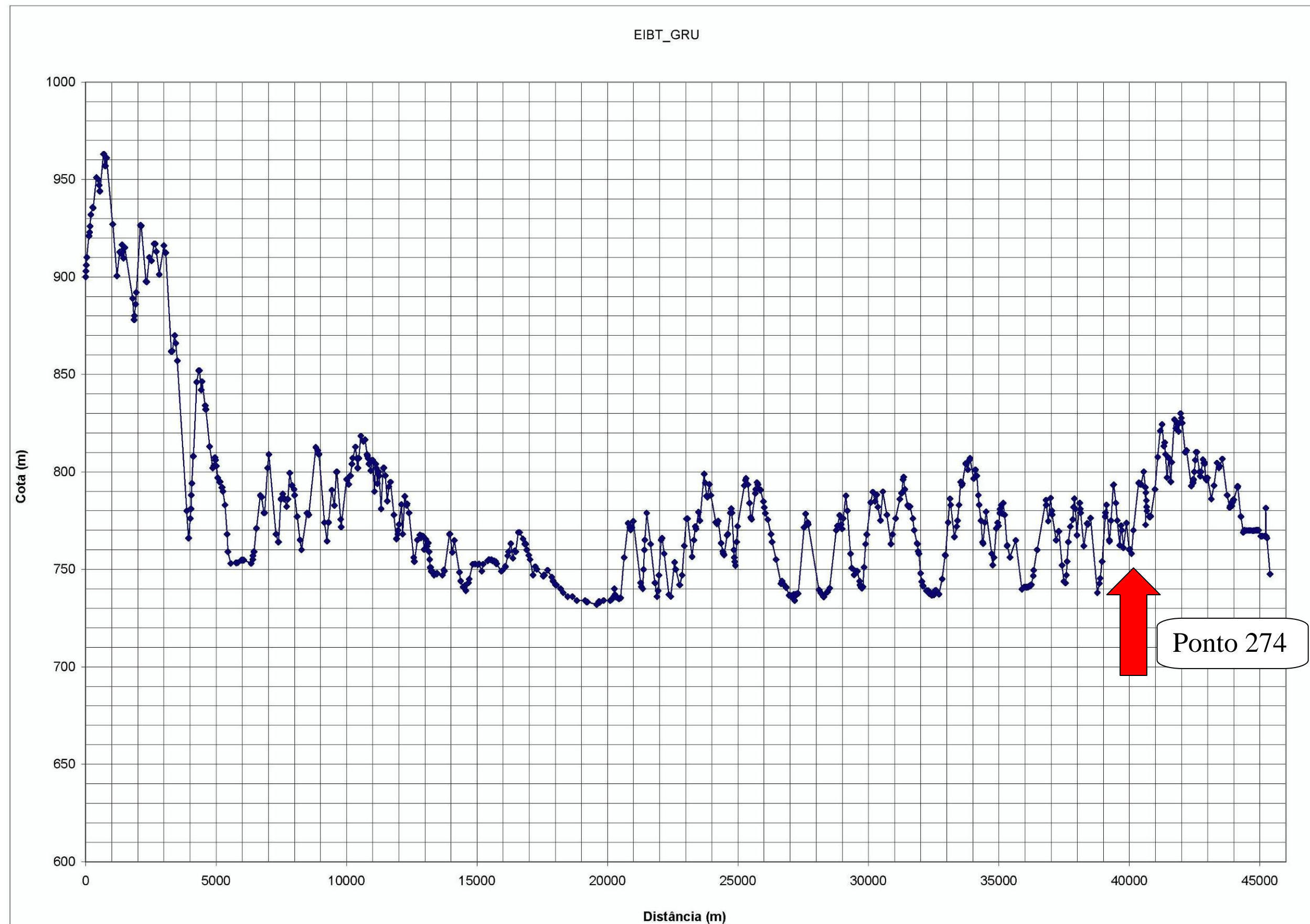
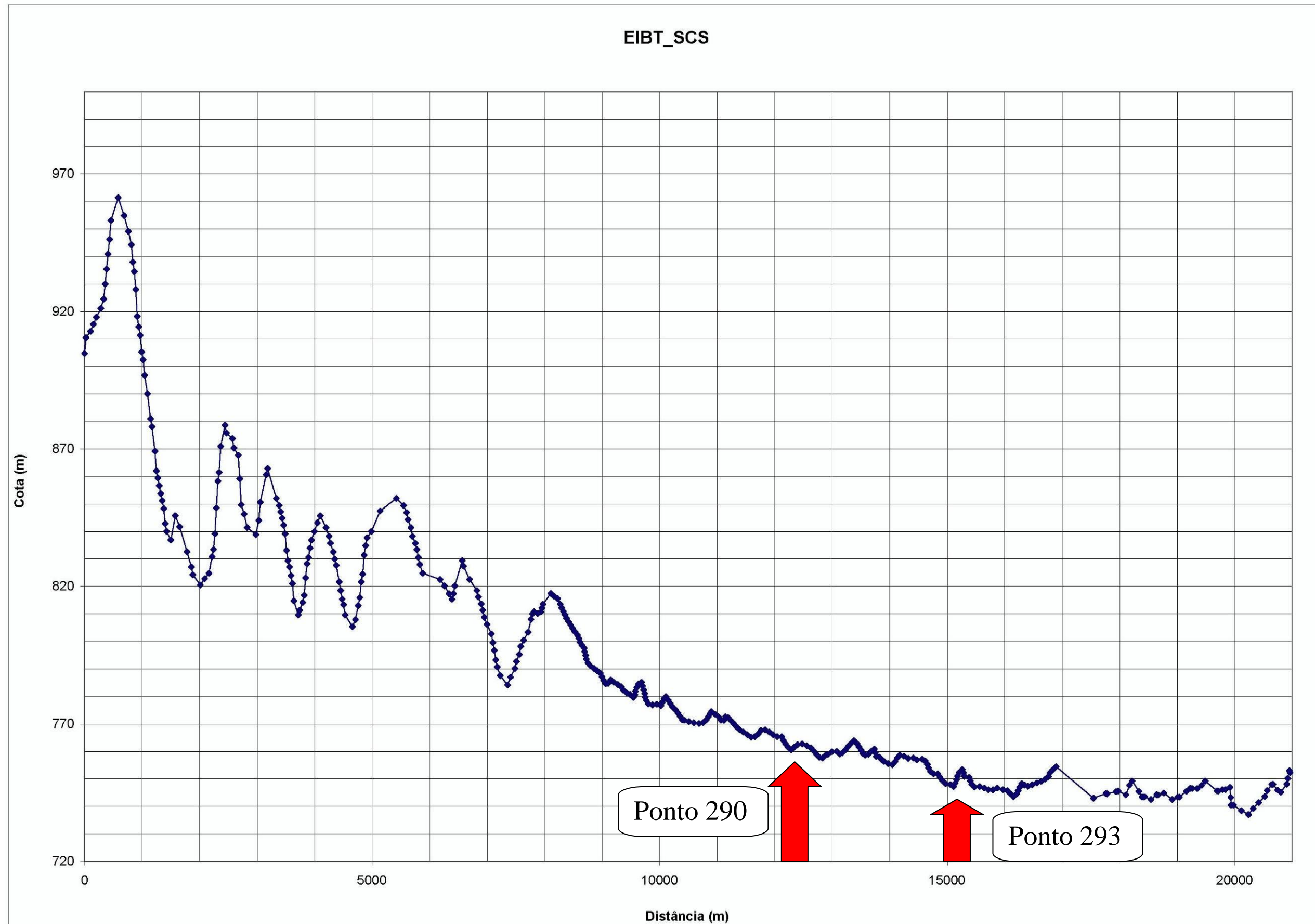


Figura C - 6: Perfil do duto de etanol km - Trecho EVL1 - EIBT



**Figura C - 7:** Perfil do duto de etanol - Trecho EIBT GUARULHOS



**Figura C - 8:** Perfil do duto de etanol - Trecho EIBT - SÃO CAETANO DO SUL

**Tabela C - 1: Cálculos PT - 27**

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 1	548	70	552	
PICO 2	548	10	548	
PICO 3	479	6	479	
PICO 4	68	8	69	
PICO 5	548	12	548	
PICO 6	479	27	480	
PICO 7	411	3	411	
PICO 8	274	12	274	
PICO 9	548	10	548	
PICO 10	68	2	69	
PICO 11	205	22	207	
<b>Somatório</b>			<b>4186</b>	<b>1663</b>

**Tabela C - 2: Cálculos PT - 104**

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 1	685	11	685	
PICO 2	479	31	480	
PICO 3	479	10	480	
PICO 4	685	19	685	
PICO 5	274	13	274	
PICO 6	479	3	479	
PICO 7	822	18	822	

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 8	685	32	686	
PICO 9	205	14	206	
PICO 10	411	53	414	
<b>Somatório</b>			<b>5212</b>	<b>2070</b>

**Tabela C - 2: Cálculos PT - PT - 274**

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 1	128	13	129	-
PICO 2	128	20	130	
PICO 3	64	8	65	
PICO 4	128	7	128	
PICO 5	128	10	129	
PICO 6	64	1	64	
PICO 7	256	27	258	
PICO 8	64	5	64	
PICO 9	128	18	129	
PICO 10	256	46	261	
PICO 11	64	10	65	
PICO 12	256	35	259	
PICO 13	321	36	322	
PICO 14	128	6	128	
PICO 15	256	24	258	

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 16	32	3	32	
PICO 17	32	2	32	
<b>Somatório</b>			<b>2553</b>	<b>80</b>

**Tabela C - 2: Cálculos PT - 290**

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 1	146	5	146	
PICO 2	205	3	205	
PICO 3	88	2	88	
PICO 4	175	6	176	
PICO 5	29	5	30	
PICO 6	292	8	292	
PICO 7	585	25	585	
PICO 8	263	10	263	
PICO 9	351	25	352	
PICO 10	117	8	117	
PICO 11	263	16	264	
PICO 12	556	87	562	
PICO 13	175	3	175	
PICO 14	58	1	58	
<b>Somatório</b>			<b>3314</b>	<b>242</b>



**Tabela C - 2: Cálculos PT - 293**

	HORIZONTAL (m)	VERTICAL (m)	DIAGONAL (m)	VOLUME (m <sup>3</sup> )
PICO 1	205	3	205	-
PICO 2	88	2	88	
PICO 3	175	6	176	
PICO 4	29	5	30	
PICO 5	292	8	292	
PICO 6	585	25	585	
PICO 7	263	10	263	
PICO 8	351	25	352	
PICO 9	117	8	117	
PICO 10	263	16	264	
PICO 11	556	87	562	
PICO 12	29	1	29	
PICO 13	88	3	88	
PICO 14	29	2	29	
PICO 15	117	1	117	
PICO 16	175	5	176	
PICO 17	146	4	146	
PICO 18	146	6	146	
PICO 19	58	1	58	
<b>Somatório</b>			<b>3724</b>	<b>272</b>