Vinidex Systems & Solutions

Vinidex Pty. Limited
A.BN 42 000664942
19-21 Loyalty Road, (PO Box 4990)
North Rocks, NSW. 2151, Australia

TECHNICAL NOTE

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ENERGY REQUIREMENTS FOR PVC AND DUCTILE IRON PIPE

Introduction

These days, products are increasingly being evaluated on the basis of their environmental impacts as well as their technical suitability for a given application. For a thorough evaluation, a methodology known as Life Cycle Assessment is being developed and used. This approach examines the environmental impacts of a function for every stage of the life of a product from extraction of raw materials to eventual disposal or recycling of the materials of construction. An example of this type of analysis is the recent report " Environmental Life Cycle Assessment of Gas Distribution Systems" published by GASTEC.[1]

Often, other types of environmental comparisons are made between products. For example, energy used in manufacture or greenhouse gas emission. It should be noted that caution should be exercised in drawing conclusions from such analyses as they present an incomplete picture of the environmental impacts and may be misleading.

There have been two articles published by A Williams which deal only with the energy requirements for the manufacture of Ductile Iron, PVC and Polyethylene Pipe Systems.[2,3] Both conclude that Ductile Iron pipes use significantly less energy in manufacture than PVC pipes. However, even within the limited scope of the comparison, these conclusions are misleading and the numerical values used require further discussion.

Ductile Iron

In the first article [2], the energy equivalent value of ductile iron is given as 23 GJ/tonne which is calculated from the purchased energy for Australian production of ductile iron pipes. To obtain this value, the analysis starts at the factory gate on the basis that ductile iron is made from 100% scrap. This means that all of the energy associated with mining and new iron production is allocated to the first product life and none to the pipe. It would seem essential then, that any energy associated with operations for converting the old products into useable scrap (such as sorting, crushing and transporting) be allocated to the pipe. However, it appears that none has been taken into consideration.

The energy value does not include energy associated with the manufacture of the cement mortar lining, which is said to require only 1.3 GJ/tonne and therefore only result in a 2% increase. Note that this energy requirement for cement mortar is contradicted in the other article[3] which quotes 8.5 GJ/tonne for cement mortar although it unclear whether it is considered in the calculations here either[*].

For the comparison to be valid, the total energy equivalent for ductile iron pipe manufacture, including the manufacture and application of cement mortar, external paint and internal seal coating systems and polyethylene sleeving would need to be considered since the pipe relies on these additional products for serviceability.

PVC

The energy equivalent value used for PVC [2] is taken from a reference and then adjusted for the efficiency of the electricity generation

[*] The paper gives an energy equivalent value for the more efficient British iron production, then quotes the energy value for cement mortar of 8.5GJ/tonne and states that the analysis which follows is for lined pipe. However, elsewhere in the document the quoted energy value used in the comparison is given. The value is numerically equivalent to the iron production value and therefore the analysis appears to be for unlined pipe. This is an apparent contradiction and since no calculations are given, it is not possible to determine whether or not the lining is included

The calculations in this Technical Note use the energy equivalent values for Australian Ductile Iron manufacture and the 8.5GJ/tonne value for cement mortar which is given as a complete energy equivalent value.

industry giving a value of 117 GJ/tonne. This value is much higher than other published values. Kindler and Nickles [4] calculated an energy equivalent value for PVC of 53 GJ/tonne, taking into account the efficiencies of all utilities used in every step of manufacture from extraction of raw materials to the final polymer. They also provide a typical value for pipe extrusion of 4 GJ/tonne. This gives a total of 57 GJ/tonne. It is interesting to note that this reference is quoted in [3] for polyethylene but not for PVC.

The tables below show the calculated energy equivalent values for the manufacture of PVC and Ductile Iron Pipes using values for ductile iron and cement mortar from Williams[2, 3] and the values for PVC from Kindler and Nickles.[4]

Conclusion

The tables indicate that when cement mortar lining and other literature on PVC are considered, the energy equivalent for manufacture of ductile iron pipes is generally higher rather than significantly less than for PVC as concluded by Williams [2,3]. It should also be noted that the values for ductile iron are incomplete as discussed above and that this comparison is completely invalidated if ductile iron pipe is manufactured from other than 100% scrap.

While these results are of interest, they do not necessarily indicate the overall environmental impact of the products. This can only be achieved by doing a full life cycle assessment of the products used to perform a particular function. The recent study by GASTEC[1] in the Netherlands on gas distribution systems compared the environmental performance of Ductile Iron, PVC and Polyethylene concluding: 'In general, nodular iron scores worst. On a large distance PE-80 and PVC follow, where PVC scores the best.' (See Vinidex Technical Note VX-TN 15A.0)

References

[1] van den Berg, N. W., Huppes, G. and Wikkerink, J. B. W., 'Environmental Life Cycle Assessment of Gas Distribution Systems.' Gastec N.V. and CML-S&P, January 1996.

[2] Williams, A., 'Energy Requirements for PVC and Ductile Iron Pipe Systems', Water, Journal of Australian Water and Wastewater Association, June 1991, p38

[3] Williams, A., 'A Comparison of Energy Requirements for Making Polyethylene, Unplasticised Polyvinyl Chloride and Ductile Iron Water Pipes', Inst. Water Officers Journal, Vol 28, No. 2, 1992, p8-11

[4] Kindler, H., and Nickles, A., 'Energy requirements in the production of materials - Fundamentals and energy equivalent values for plastics.', Translated from Kunststoffe 70, 1980, 12, p802-807.

DN 100 Pipe	**DICL**	**PVC**		
Pipe Class	Class K9	Class 12	Class 16	Class 20
Mass of pipe material/ pipe length (kg)	91	22.5	29.1	35.1
Mass of lining material /pipe length (kg)	121 - 91 = 30	-	-	-
Energy equivalent of pipe material GJ/tonne	23	57	57	57
Energy equivalent of lining material GJ/tonne	8.5	-	-	-
Energy equivalent GJ/ metre length of pipe	0.38 + 0.046 = 0.42	0.21	0.27	0.33

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DN 150 Pipe	DICL	PVC		
Pipe Class	Class K9	Class 12	Class 16	Class 20
Mass of pipe material/ pipe length (kg)	138	47.8	61.5	74.1
Mass of lining material /pipe length (kg)	183 -138 = 45	-	-	-
Energy equivalent of pipe material GJ/tonne	23	57	57	57
Energy equivalent of lining material GJ/tonne	8.5	-	-	-
Energy equivalent GJ/ metre length of pipe	0.58 + 0.07 = 0.64	0.45	0.58	0.70

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Correspondence regarding this Technical Note should quote the reference number and version and be directed to:

The Technical Manager
Vinidex Pty Limited
Technical Services Group
254 Woodpark Rd.'
Smithfield, NSW, 2164
Australia

Tel +61(0)2 9604 2422
Fax +61(0)2 9725 3363
Email techman@vinidex.com.au