ADDITIVES SUSTAINABILITY FOOTPRINT (ASF): a methodology for the increasingly sustainable choice and use of substances

A number of established assessment systems and approaches, commonly used in the chemical sector, have been identified to test a number of criteria relevant for sustainable development (LCA, EPD, PEF, EU REACH, etc.).

A new tool has been developed to evaluate the sustainability (positive contributions and residual risk) of the use of additives in the production of articles. Although developed for PVC products, a peer-reviewed article highlights the relevance of this approach for other materials:

- Additive Sustainability Footprint (ASF) = Developed for the evaluation of the sustainability of the use of PVC additives throughout the entire life cycle of PVC articles and based on scientific sustainability principles applied at each stage of the life cycle, the ASF is based on pre-existing tools with generic applicability to chemicals (Everard & Blume, 2019).Motivi/Motivazione

Both primary material and additives, at any stage from formulation to composition and additions during the useful life, can have implications for the circularity of a product when it reaches the end of its useful life. The use of additive substances introduced at any stage of the life cycle can influence the sustainability of a product as a whole, for example through parameters such as emissions into the atmosphere or water, wider impacts on the environment and human health during the entire life cycle from extraction, production, use and through to disposal or recycling.

The Natural Step (TNS: an international sustainable development company) and VinylPlus (the voluntary commitment of the European PVC industry) have jointly developed the Additives Sustainability Footprint (ASF) methodology to analyse how individual additive substances can impact the sustainability of a product throughout its entire life cycle, providing practical guidance on sustainable materials management and innovation to address the circular economy.

The application of ASF enables PVC converters to gain information about the sustainability of additives and the supply chain, which can guide the choice of formulations. The adoption of ASF methodology in product design thus directly influences ECODESIGN.

Listed below are the criteria considered important for the overall assessment of sustainable development underlying the ASF approach, along with the rationale for their inclusion:

- All dimensions of sustainable development-social, economic, and environmental criteria-are relevant to sustainable development: these dimensions must be addressed in an integrated manner
- Transparently based on science = A sound scientific basis to avoid subjectivity or opinion
- A life-cycle risk approach, rather than a simplistic assessment of hazard potential: risk through a life-cycle exposure assessment of the entire item, may mean that potentially hazardous substances pose no threat due to low or no exposure
- Positive contributions to meeting human needs: in addition to negative implications, the purpose for which chemicals are used is to promote outcomes with positive benefits for Sustainability
- Open access: methods are communicated openly, replicability and testing can be achieved

- Applicable to all products and/or materials: To be useful in all applications, tools and/or approaches must be flexible for use across all products and materials
- Peer-reviewed: Peer-review in external scientific literature is a gold standard for testing scientific credibility

Description

Four sustainability principles are derived from the science-based TNS model. These define that, in a fully sustainable society, nature must not be subject to: 1_systematically increasing concentrations of substances extracted from the earth's crust; 2_ systematically increasing concentrations of substances produced by society; 3_degradation by physical means of nature that can disturb natural cyclical processes; and there must not be 4_structural obstacles to people's health, skills, impartiality that compromise safety and opportunities in the present and/or in the future, preventing people from satisfying their needs.

The lack of assessment of the use of additive substances in the context of both the entire life cycle of the product and taking into account sustainability criteria beyond narrow environmental factors has made it necessary to innovate ASF as a tailor-made tool to address the challenge of the sustainable use of substances. Whilst the development of ASF was pioneered to support voluntary sustainability commitments for PVC, the underpinning principles are generic and can be extended to all additives to a range of substances. Examples of the illustrative extension of ASF to a wider suite of materials can be found in the book *Seeking Sustainable Development on a Level Playing Field*[1].

Taking PVC as a reference, it can be said that "The Additive Sustainability Footprint® (ASF) is a methodology to proactively assess and promote the sustainable production and use of PVC additives throughout entire product lifecycles, including the roles of additives in the performance of PVC products". The six stages of the ASF analysis are: 1) Raw materials extraction 2) Additive production 3 Transport and packaging 4) Compounding phase 5) Product durability 6) End-of-life management. The ASF analysis compares the 4 rules of a sustainable society with the 6 stages of the product life, revealing both the current contributions of the additive (both beneficially and risks to be address) and informing innovations that progress towards a vision of fully sustainable use (as illustrated below).

Results

The results of the analysis are highlighted through the use of 'traffic lights' colour coding, signifying whether the sustainability-relevant principle is fully met (green), partially met (yellow) or not met (red).

[1] Everard, M. (2024). *Seeking Sustainable Development on a Level Playing Field: A PVC Case Study*. Routledge.

The application of ASF to an article made with PVC (an electric cable) informed significant improvement in additive formulation by highlighting whether the use of one or more substances fully met (green), partially met (yellow) or did not meet (red) the four TNS sustainability principles in each of the 6 article life cycle stages, as summarized in the following diagrams.

The past

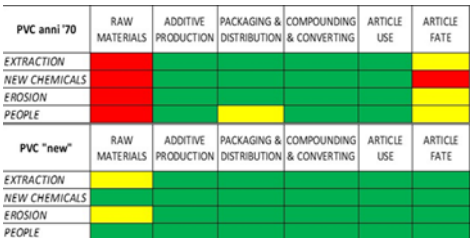
PVC Insulation	phr
PVC S K70	100,0
DIDP	36,0
$CaCO_3$	50,0
Calcinated clay	10,0
MCCP	12,0
ATO	4,0
Zinc Borate	2,0
CaZn stabilizer	4,0
Lubricant	x
Pigment	x

- ATO = H351, H373
- Zn Borate = H361-d, H341
- MCCP = H362

The present

PVC Insulation	phr
PVC S K70	100,0
DIDP	44,0
$CaCO_3$	15,0
Calcinated clay	10,0
MDH	35,0
ATO-Free Flame Retardant	10,0
CaZn stabilizer	4,0
Lubricant	X
Pigment	X

ATO-free FR = not classified



ASF can also highlight further opportunities to improve the sustainable use of the additive throughout the article life cycle, for example by promoting increased recycling to recover additive within recyclate for beneficial reuse at end-of-life.

The principles embedded within the ASF approach are generic. ASF is therefore relevant not only to the assessment of other additives in other PVC articles, but also to substances added to the many other types of material (such as other polymers, metals, ceramics or timber) used by society to address a diversity of needs.

Replicability

There are no limits for the replicability of the ASF method if the principles defined by the operating procedure developed are strictly applied.

It can be applied to any production process in which substances/additives are used.

Barriers to use

There are no limits to the adoption of the ASF method, beyond ensuring that it is applied rigorously (for which some training may be required). ASF is above all an innovation tool, intended to help all those involved in the full article value chain change behaviors in the choice, innovation and wise use of substances.

Enhancing connections along value chains

The architecture of ASF addresses the sustainability implications of additives in the context of the full societal life cycle of the articles into which they are integrated. Consequently, ASF can promote a collaborative approach, transparently identifying how improvements by all stakeholder involved in full article life cycles – for example additional inputs at the manufacturing stage, maintenance inputs in the use phase, recovery when articles have reached the end of their useful life, the impacts of energy sources at all life cycle stages – can contribute to sustainability improvements.

Key words

Sustainability, Ecodesign, climate change, circularity, environmental and health impact, pre- and post-consumer recycling, PVC.