PIPES SCRAPING: FUNCTIONALITY AND ENVIRONMENTAL INTEREST

J.M DESSEIGNE[1], S. PENAVAYRE[1], V. COUVENT[1] , G. WAIDELICH[2], X. DILME[3]
With the technical collaboration of E. ENRIC BARTRA SEBASTIAN (INCAVI, Spain), A. LUIS CERDEIRA (CVRVV, Portugal), Dr. Z. KERENYI and Dr. A. SZABO (CORVINUS UNIVERSITY BUDAPEST, Hungary).

[1] IFV, Domaine de Donadille, 30230 Rodilhan Jean-michel.desseigne@vignevin.com
[2] INWaG, Welzenwiler Str. 7/4, 72074 Tübingen. Inoxpa. Gwaidelich.de@inoxpa.com
[3] Inoxpa, C/ Telers, 54,Aptdo. 174, 17820 BANYOLES (GIRONA). Xdilme@inoxpa.com

I/ Introduction

During the winemaking process, grapes, musts and wine undergo numerous transfers. These transfers are in the majority of the cases realized with pumps in flexible food plastic pipes, and occasionally in fixed stainless steel pipes. At the end of the transfer, a draining of the pipes must be realized to limit products losses. This draining must be carried out without qualitative depreciation risks (mixings, oxygen dissolution, mixtures or dilutions). In the cellars, depending on the pipes configurations (diameters, lengths, materials), several practices are used: manual draining by handling the pipes, pump draining with pushes with air (no-load operation of the pump), pushes with water, pushes with gas (air, nitrogen). After use, a preliminary wash with water (rinsing) with strong flow must be carried out to avoid the drying and the fixing of the dirt. According to the risks and the hygiene level decided, the rinsing must be followed or not of a cleaning and/or a chemical disinfection. The implementation of these hygiene processes requires great quantities of water and chemicals.

In food industry, the technique of scraping, or “pushing with a sphere”, is implemented more and more. The advantages highlighted are to facilitate the recovery of the products and to avoid the mixtures of products, while reducing water consumption, pollutant load of the effluents, and an interesting investment return. In wine industry, this technique remains little developed, primarily used on fixed stainless steel pipes for long-distance transfers (overhead or underground pipes).

The Company Inoxpa developed PIG system, a specific recovery system for wine industry, for flexible and fixed pipes. The aim of the study is to show the interest of this process, in particular in term of functionality and on environmental aspects (reduction of water consumption, reduction of volume and pollutant load of the effluents). The tests are carried out on flexible pipes.

Description of the Inoxpa Company’s PIG system

The PIG system is composed of a launcher, a receiver and a spherical shell out of food silicone. The spheres are introduced in the pipe on the level of a connection, using the launcher in form of T. The gas is injected via a valve and propels the sphere in the pipes. This last pushes the wine inside the pipes. On arrival, the sphere is blocked in the cylindro-conical receiver and ensures the sealing, avoiding the return of the wine in pipes.

Various configurations are proposed:

- In manual configurations (the simplest), the sending and the reception are carried out by the operator (figure 1).
- In more automated systems, the unit can operate without manual interventions, the sphere remaining permanently in the circuit (storage stations) (figure 2).

Figure 1: Inoxpa's PIG system. Manual configuration.

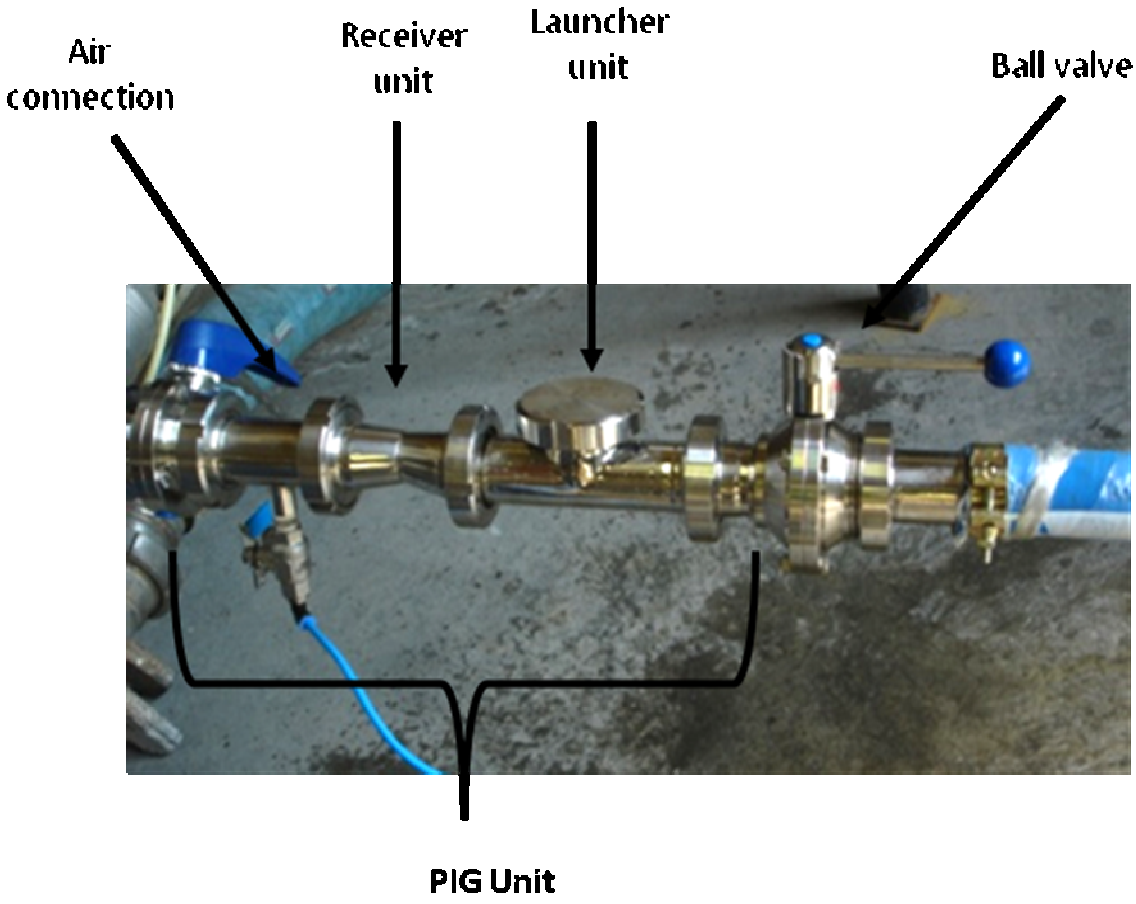


Figure 2: Inoxpas' PIG System. Automated system

II/ Material and methods

The process transfer, initially only used on fixed stainless steel pipes, on flexible pipes, required preliminary settling tests. One of the difficulties is indeed the risk of the sphere blocking in pipes, on the level of the connections or on the level of deformations or variations of the pipe's interior diameter. In order to evaluate the scraping process effectiveness and reliability, the tests were carried out on big length pipes, with numerous connections: 24 linear meters of DN50 pipes, composed of 4 flexible translucent PVC tubes of 6 meters, interconnected with ligatured connections of the type DIN.

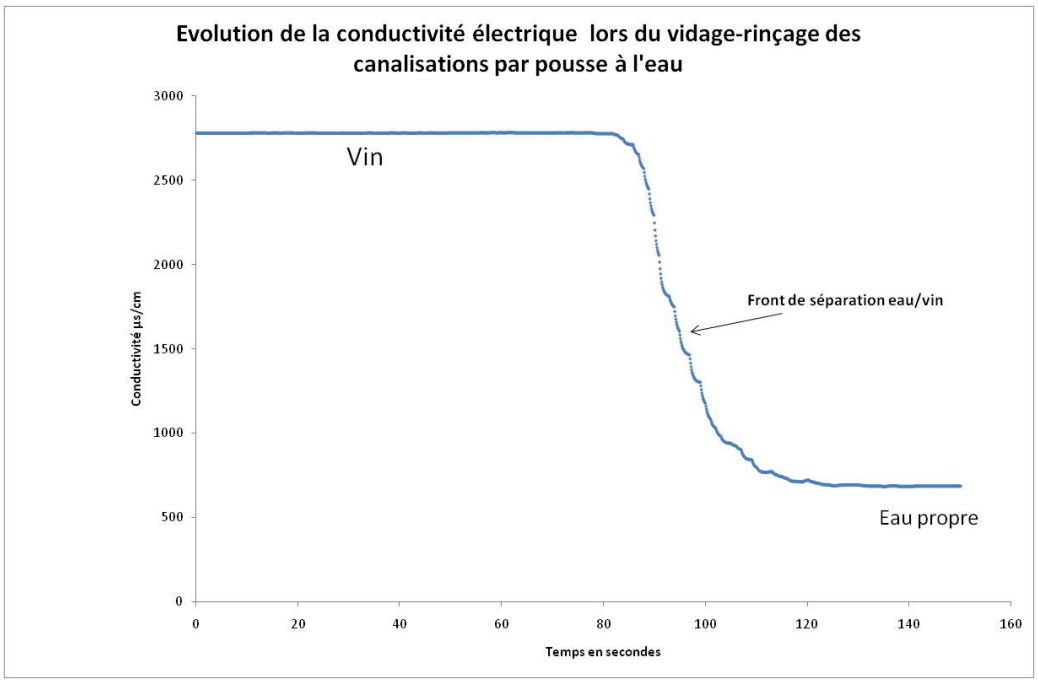
The PIG system performances are compared to the various draining methods: manual draining, draining with pump (dry operation), draining by pushes with water and draining by pushes with gas (air and nitrogen). In order to study the process reliability and practical interest, demonstration tests were realized in 16 cellars in 4 countries, the system being compared to the device draining practiced in each cellar.

The rinsing effectiveness and the necessary water quantities are evaluated by visual observations and by determination of the physic-chemical main features of rinsing waters (electric conductivity, pH, turbidity, coloring intensity, ATP). The rinsing was determined as finished when the rinsing waters do not involve dirt any more (wine, cleaning/disinfection products) and thus when they have the same characteristic of clean waters used for the rinsing. Table 1 shows that electric conductivity is a reliable and fast method for checking rinsing waters quality, because it allows detecting contaminations of 0,5%, visually no observable. Conductivity measure can also be realized on line.
Rinsing are carried out under hydrodynamic conditions supporting mechanical actions during the rinsing water flow in the pipes (Reynolds number Re>30 000, flow rate>0,7m/s for DN50 pipes).

*Table 1: Example of the physic-chemical characteristics of rinsing water according to their pollution (red wine traces).*ATP: Adenosine triphosphate. Evaluation of ATP quantities by bioluminescence expressed in RLU (relative light units).*

Wine traces (%)	Conductivity (µS/cm)	pH	Turbidity (NTU)	Coloring intensity	ATP* (RLU)	Visual aspect
0	666	7.6	0.13	0	15	Clean water
0.05	668	7.6	0.45	0.03	29	Clean water
0.1	670	7.7	0.50	0.04	95	Clean water
0.5	680	7.6	0.70	0.13	nd	Grayed
1	690	7.3	1.32	0.25	nd	Grayed
2	716	7.2	2.33	0.43	162	rose

Figure 3: Evolution of the electric conductivity during pipes emptying/rinsing by pushes with water. An acquisition every 100ms.

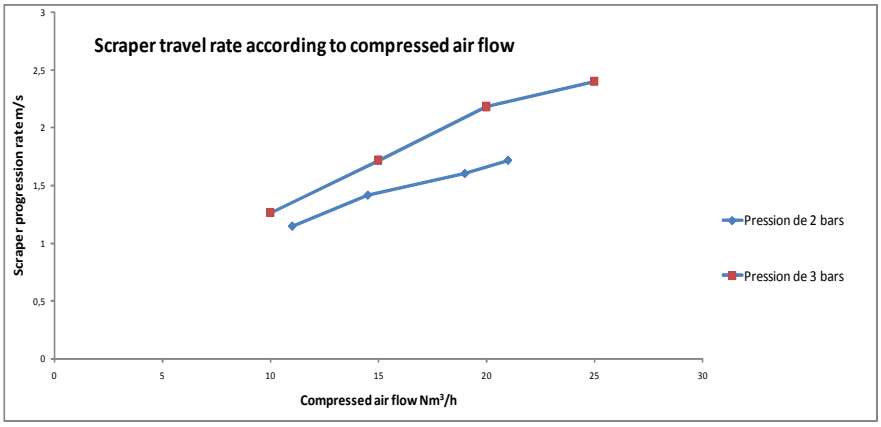


III/ Results

The PIG system process must ensure the pipes draining, without blocking the sphere. At the end of the pushing, the sphere must be blocked in the receiver, in order to ensure the sealing at the level of the tank and allow its recovery.
Seven spheres, of different configuration and composition, were tested. Rectangular polyethylene sphere with flexible lips ensure the best rate of recovery, but are difficult to introduce in the pipes. Spherical flexible silicone sphere, of weak Shore index and of diameter slightly higher than the internal pipe's diameter, ensure very good rate of recovery, but are not stopped at the level of the receiver, which is a major disadvantage. They are found in the tank. It is the same for the foam sphere. Spherical sphere in average hardness silicone (Shore index 65°), and with a diameter close to the pipes nominal one, are functional. They were selected for the continuation of the tests.

Spheres progression in pipes requires energy to be opposed to the friction forces in the pipes and to overcome the hydrostatic pressure. The rise in the applied pressure results in a better effectiveness: rate of the sphere travel, absence of blocking. The air compressed pressure must however be limited to some bars (1 to 2 bars) for safety reasons. We highlighted that the process reliability is closely related to the air flow. As figure 4 underline it, with identical pressure, the sphere travel rate is proportional of the compressed air flow. When air flows are too low, or in case of interior diameter contracting (pinching, internal deposits), the spheres are frequently blocked at connections level. The optimum adjustment is a pressure from 1 to 2 bars, to adapt according to the backpressure to overcome (hydrostatic pressure), and flows from 10 to 20 m3/h, for a sphere travel rate from 1.5 to 2m/s.

Figure 4: Gas flow influence on the process effectiveness.



Effectiveness of products recovery

The PIG system process allows recovering approximately 97 to 98% of remaining volumes in pipes (CF. table 2). The wine present in pipes in sent out of tank, without risk of mixture/dilution or oxygen dissolution. Comparatively, the pipes draining by pump with pushes with water generates very variable losses (from 7 to 20% of the pipes volume during our tests), a mixture water/wine being created with the separation face. In case of a no-load operation of the pump, residual volumes can be very variable according to the conditions of use, from 5 to 30% during the realized tests. This practice is linked to the incorporation in the tank of great air quantities. In the case of a pushes with gas draining (air or nitrogen), the remaining volumes in pipes are function of the configurations (18 to 20% during our tests). In these last two cases, the residual volumes recovery after a partial draining requires a manual operation (progression along the transfer line) after closing the tank valve.

Table 2: Scraping system performances on the wine recovery rate and water consumption.

Cellar	% of wine recovery with PIG System	% water consumption reduction
Cellar 1	98 %	70 %
Cellar 2	98 %	98 %
Cellar 3	97 %	70 %
Cellar 4	97 %	81 %
Cellar 5	98 %	75 %
Cellar 6	99 %	75 %

Effectiveness of the rinsing/cleaning

With the PIG system process, the pipe draining is realized by scraping with “dryness”, without use of water. After use, pipes must however be rinsed with water, rinsing followed is necessary of a cleaning/chemical disinfection process. The rinsing is carried out by introducing in pipes a water volume and by realizing a pushes with the sphere. The sphere progression allows to carry out a complete and efficient rinsing of the pipes, thanks to the mechanical actions carried on the walls and at flow rates allowing the dirt elimination. It is thus possible to realized efficient rinsing with low water volumes (20% of the pipes volume during our tests). At the end of the push, pipes do not contain residual water any more, which is favorable to hygiene. In case of cleaning and/or chemical disinfection, wastes water can be collected at the end of the pipes, and possibly recycled.

Water consumption

Water savings thanks to the PIG system process in the 6 cellars where tests were carried out, appear in table 2. Compared to usual draining and rinsing practices in cellars, water savings vary from 50 to more than 80%.

During the pushes with water, the water volume used is at least the pipes volumes in order to ensure the pushing and the rinsing. This practice, which limits oxygen dissolution risks but requires the operator vigilance to avoid the mixture water/wine, generates very important water consumption.

An efficient pipes rinsing requires full pipes and a strong flow rinsing. A rinsing with scraper can thus make it possible to reduce water consumption for this operation of more than 80%.

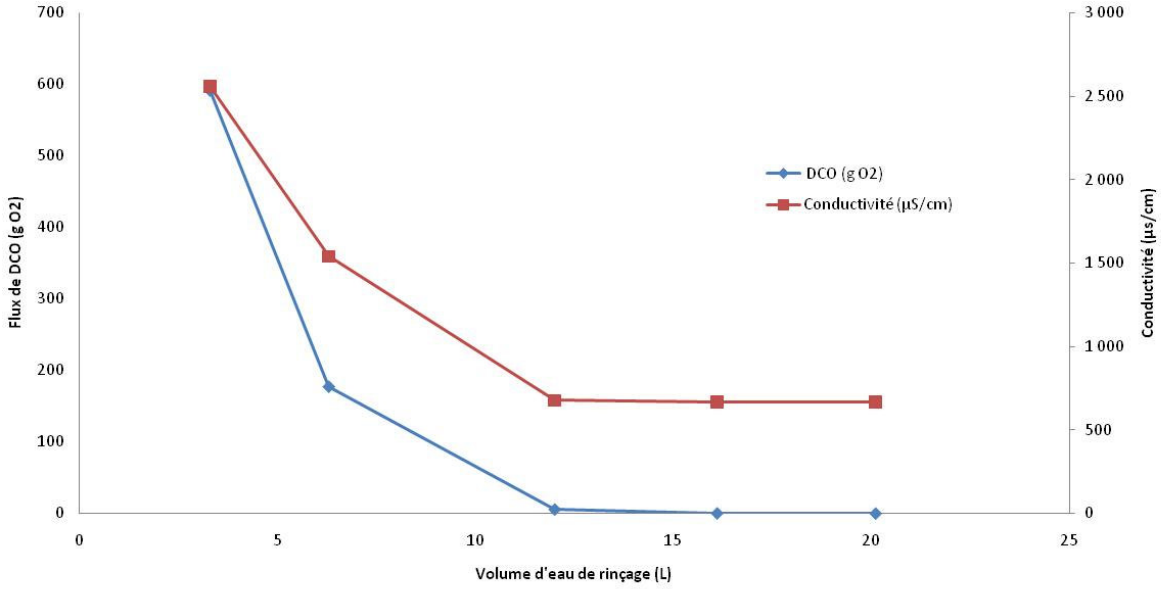
Volume and pollutant load of the effluents

Pipes rinsing generates effluents whose volume vary according to the quantities of water used. These effluents pollutant load is primarily composed by organic matters from wine losses remaining in the pipes after draining. As table 3 and figure 5 show, the use of a “pushing with a sphere” system should allow to reduce very significantly pollution flows, by a factor 2 to 10 during our tests.

Table 3: Pollution flows generated by rinsing

Volume and pollutant load of the effuents		Volume (L)	Chemical Oxygen Demand (COD) flow (g O_2)	Suspensed solid flow (mg)
Test 1	**Rinsing by pump**	42	548	1344
	Rinsing by scraper	11	331	687
Test 2	**Rinsing by pump**	70	158	805
	Rinsing by scraper	2	14	100

Figure 5: Evolution of the pollutant (COD flows) load of waters during rinsing.



Conclusion

Scraping or “pushing with a sphere” systems can be used for pipes draining and cleaning. They allow to recover and to send in the tank the almost totality of the residual volumes remaining in the pipes after transfer operations, without qualitative depreciation and water/wine mixture risks. They also allow an efficient cleaning, while limiting quantities of water used and the pollutant load of the effluents.

Implementing a pipes scraping system requires some conditions. Tubes must have the same diameter, without throttling (bad quality welding, valves, butterfly valves…). The process in functional on flexible pipes, but requires adapted tubes and particular implementation conditions (launcher, receiver, scraper) which were validated during this study with Inoxpa Company.

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Abstract
Conciliate the reduction of the environmental impact of wine industry and its business' competitiveness; such is the objective of 12 European stakeholders involved in the Winenvironment project[1], coordinated by the French Institute of Vine and Wine (IFV). The project aims to demonstrate the interest of new practices and technologies, significantly acting for reducing resources consumption (water, energy) and pollutions, while providing better performances. Thus, transfer operations were the subject of an experiment. Indeed, particularly common in the cellars, they generate important water consumption and potentially pollutant effluents, especially during emptying and cleaning operations. The PIG system (recovery system) developed by INOXPA, had been tested in 16 cellars, on flexible pipes. It allows the recovery of almost all products, without qualitative impairment risk and limits products losses. So it definitely presents an economic interest. This reduction in wine loss has another consequence: the reduction in organic pollution of the effluents. It also allows an efficient pipes cleaning and limits water consumption during rinsing operations. The process is functional but requires particular implementation conditions, especially on flexible pipes, these conditions had been specify during the study.
Key words: Eco-Innovation, Transfer, Wine, Must, PIG System, Pipes scraping, Environment

Résumé
Concilier réduction de l'impact environnemental de la filière vitivinicole et compétitivité de ses entreprises, tel est l'objectif poursuivi par 12 acteurs européens de la filière, dans le cadre du projet Winenvironment[2] coordonné par l'IFV. Le projet a pour objet de valider l'intérêt de nouvelles pratiques ou technologies, agissant significativement sur la réduction des consommations en ressources (eau, énergie) et des pollutions, tout en fournissant de meilleures performances. Dans ce cadre, les opérations de transfert ont fait l'objet d'expérimentations. En effet, ces dernières, particulièrement fréquentes dans les caves, engendrent des consommations d'eau importantes et génèrent des effluents potentiellement très polluants, notamment lors des opérations de vidange et de nettoyage. Le procédé développé par la société Inoxpa PIG system ou système de raclage des canalisations a été expérimenté sur tuyaux souples dans 16 caves. Il permet la récupération de la quasi-totalité des produits, sans risque de dépréciation qualitative et donc limite fortement les pertes en produit, d'où un intérêt économique certain. Cette réduction de perte de vin se traduit également par une forte réduction de la pollution organique dans les effluents. Il permet également un nettoyage efficace des canalisations et limite fortement les consommations d'eau lors des opérations de rinçage. Le procédé est fonctionnel, mais nécessite des conditions de mise en œuvre particulières, notamment sur canalisations souples, conditions qui ont été précisées lors de l'étude.
Mots clés : Eco-Innovation, Transfert, Vin, Moût, Système PIG, Raclage des canalisations, Environnement.

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