

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

OMEGA LINER COMPANY, INC.,

Petitioner

v.

BUERGOFOL GmbH

Patent Owner.

CASE NO.: IPR2023-01372
U.S. PATENT NO. 9,657,882

DECLARATION OF ABDEL-KADER BOUTRID

I, Dr. Abdel-Kadel Boutrid, do hereby declare:

1. I am making this declaration at the request of Buergofol GmbH (Patent Owner) to provide the details of the experiments that were conducted by me or under my supervision that formed the basis for the data presented in U.S. Patent No. 9,657,882 (“the ’882 patent”), of which I am a named co-inventor.
2. I am a German citizen and currently reside in Siegenburg, Germany.
3. From September 1998 to the present I have been employed by Buergofol GmbH, owner of the ‘882 patent. After April 2024, my employment status changed from employee to senior consultant in compliance with German labor and retirement laws. My current job title is “Head of Research and Development”. I am responsible for product development and quality control. My job responsibilities also include overseeing how blown extrusion films are manufactured by Buergofol, the majority of which are for food packaging but also include inner film and outer film usable for making ultraviolet cured-in-place pipe (“UV-CIPP”) liners for use in trenchless sewage pipe renovation.
4. Prior to working at Buergofol GmbH, I was employed by Veba Oel AG Gelsenkirchen (now British Petroleum) in Gelsenkirchen, Germany. From 1993-1998, I worked in the Environmental Management group at Veba Oel.
5. I studied as an undergraduate for four years in Liège, Belgium, and received a “Licence en Chimie” degree in chemistry in 1986. In 1993, I received a Ph.D

in chemistry from the Universität-Gesamthochschule Essen (now Universität Duisburg-Essen) in Essen, Germany.

A. Recognition Of The Problem and Conception For US Patent No. 9,657,882 B2 ('882 Patent) [Exh. 1001]

1. Inner Tubular Film in the Art Prior to Recognition of the Problem

6. The '882 patent relates to multi-layer tubular films having at least a homo- and/or co-polyamide as an external layer adjacent to a carrier material that is impregnated with a curable resin. The main use of such films is as an inner tubular film for insertion tubes with the curable resin being cured with UV radiation. The UV-curable resin typically includes styrene, which can be toxic and can be prevented from escaping from the resin by a layer of a homo- and/or co-polyamide. Consequently, the multi-layer tubular films used as inner tubular film of insertion tubes for UV-CIPP typically have an outer polyamide layer adjacent to the UV-curable resin, an inner polyethylene layer, and one or more layers, such as an adhesion promoter layer, between the outer polyamide layer and the inner polyethylene layer.
7. The external outer layer of UV-CIPP inner tubular film is almost always made of polyamide (as opposed to other polymers, such as polyethylene, polyurethane or polypropylene) because polyamide better blocks the styrene

that is released from the UV-curable resin, and polyamide has a higher melting point than the temperature generated by the exothermic curing reaction of the UV-curable resin. An external outer layer of polyethylene in inner tubular film would likely melt if it were next to the hot, curing UV-curable resin, which reaches a higher temperature than the melting point of polyethylenes used in inner film. A UV-CIPP inner tubular film with an external outer layer made of polyethylene that melted could not function for its intended purpose.

8. I have overseen the production of Buergofol's inner tubular film for insertion tubes for more than two decades. I have also been aware of the state of the art of inner tubular film for more than two decades.
9. On April 19, 2012, Buergofol filed a cancellation proceeding in the German Patent Office against German Utility Model Patent No. DE202010016048U1, which is related to German application no. DE10201023764.7 to which International Publication No. WO2011/157356 ("Hummel") [EX1006] claims priority. Patent No. DE202010016048U1 and Publication No. WO2011/157356 ("Hummel") have the same specification.
10. I provided testimony in the cancellation proceeding against German Utility Model Patent No. DE202010016048U1 ("Hummel") and was familiar with the inner film disclosed in that patent. I was informed and aware that German Patent No. DE202010016048U1 ("Hummel") claimed an inner film having an

inner layer with polyethylene having a VICAT softening point of 100°C or above. I was aware that Patent No. DE202010016048U1 was owned by Huhtamaki Deutschland GmbH & Co. KG.

11. I was not aware that there were any problems with the inner film as disclosed in the German Patent No. DE202010016048U1 (“Hummel”).

2. Recognition of the Problem

12. In the spring of 2012, I became aware of a problem encountered when Buergofol customers withdrew Buergofol’s inner film from the renovated pipe after the UV-curable resin cured.
13. Kurt Stark, a co-inventor on the ‘882 patent, began to work for Buergofol in October 2011. Prior to working at Buergofol, Kurt Stark worked at Huhtamaki Deutschland GmbH & Co. KG, the owner of Hummel. I worked closely with Kurt Stark regarding how to make Buergofol’s inner tubular film. From discussions with Kurt Stark, I believe that Huhtamaki had not been able, at least prior to October 2011, to make the inner film as disclosed in the Patent No. DE202010016048U1 (“Hummel”) commercially.
14. Kurt Stark and I visited two customers during the spring of 2012, who informed us that Buergofol’s inner tubular film had torn and broken off as it was being withdrawn from the renovated pipe. That was the first time that I had heard of this problem. Fragments of the inner film had torn off as the

inner film was pulled out of the cured liner. The film fragments left behind inside the pipe would block the pipe. This occurred despite Buergofol's inner film being strong because it contained a polyethylene with a relatively high VICAT softening point. Polyethylene with a higher VICAT softening point tends to be stronger and stiffer.

15. At the two customer meetings that Kurt Stark and I attended, we learned that our customers had begun using UV-curable resin that included maleic anhydride (MAH). I knew that some adhesion promoters are made of polyethylene together with maleic anhydride groups and are used to adhere polyethylene layers to polyamide layers because maleic anhydride adheres strongly to polyamides. I believed that the maleic anhydride in the UV-curable resin was probably sticking to the polyamide of the outer polyamide layer adjacent to the UV-curable resin. I believed that the solution to the tearing of the inner tubular film would be related to the outer polyamide layer as opposed to the inner polyethylene layer.
16. Kurt Stark and I believed that the maleic anhydride in the UV-curable resin could be prevented from adhering to the outer polyamide layer by creating a coating of polysiloxane or a covering of a migrating compound over the outer facing external side of the polyamide layer in order to separate the UV-curable resin in the carrier material from the polyamide. The coating or covering

would create a release effect against the adhesive resin.

17. We therefore conducted research on ways to create a coating or covering in order to increase the release effect between the outer polyamide layer of the inner film and the adhesive UV-curable resin.
18. Before my visit to the two customers during the spring of 2012, I was not aware of any customer experiencing a problem with inner film tearing when it was pulled out of the cured liner. Consequently, I was also not aware that any customer experienced a problem with inner film tearing when it was pulled out of the cured liner because the inner film stuck to the cured resin.
19. Since I began working at Buergofol in 1998, I have been responsible for quality control, and customer complaints are directed to me. Before the two customers during the spring of 2012, no customer complaints were directed to me regarding a problem with inner film tearing when it was pulled out of the cured liner.

3. Unexpected Results From Ways To Increase Release Effect

20. As we researched ways to form coatings and coverings over the outer facing external surface of the polyamide layer in order to separate the UV-curable resin from the polyamide so as to increase the release effect against the adhesive resin, we assumed that the coatings and coverings might worsen one or more important mechanical properties of the tubular film. For example, we

thought that the strength of the film might deteriorate as we added more migrating compound to the polyamide layer.

21. During our research, we were surprised when we discovered that forming a coating or covering on a polyamide-containing external layer, either by applying a coating of polysiloxane or migrating compound over the external surface, or by forming a covering of a migrating compound due to migration to the surface of the external side of the film, not only improved the release effect, which we had anticipated, but unexpectedly improved the mechanical properties of the tubular film. For example, there was a measurable increase in the elasticity of the inner film until film splice and film break. The increase in elasticity reduces the likelihood that the inner tubular film will tear as it is withdrawn from the pipe, or burst or splice when inflated during the pipe renovation procedure. The data in the '882 patent provides evidence of these unexpected properties. The experiments that were carried out by me or under my direct supervision are summarized in the '882 patent. I describe them in detail below.
22. A possible cause for this surprising and beneficial effect with regard to the mechanical properties of the inner tubular film could be an additional protective or healing effect on the external polyamide layer owing to a thin polysiloxane coating (due to coating) and also to a thin wax covering (due to

migration to the surface after wax additivation).

23. Due to these surprising properties, we submitted our findings to Buergofol to seek protection for our discovery. The '882 patent discloses our invention. Our invention includes the formation of either an external coating on the external surface of the outermost layer of the inner tubular film, or a covering that is formed when a migrating compound added to the external layer migrates to the external surface. The coating can either be of polysiloxane or of a migrating compound. The covering, however, is formed only by use of a migrating compound.

B. Testing Methods For Mechanical Properties And Release Force

1. Determination of Release Force (Release Effect)

24. To determine the release effect of the tubular film against an adhesive applied on an adhesive strip, its separating force is calculated and indicated using the unit [cN/cm] or [cN/25 mm]. The release force is the force necessary for removing (i.e., separating) the film from the adhesive. The release force compared to an adhesive is similar to the release force compared to a sticky resin, such as those used in trenchless sewage pipe renovation.
25. For the experimental determination, a test adhesive tape (width: 25 mm) was glued over the entire width of a sample of the tubular film, including inventive

and comparative films. The sample was cut in such a way that in each case, a non-glued 1-cm edge of the release film protruded on the long side of the test adhesive tape. The entire sample width was 4.5 cm (1 cm+2.5 cm+1 cm). The sample was then cut into several approximately 30-cm long strips and the sample strips were then stored at room temperature for 15 minutes.

Afterwards, the side of the sample strip that did not have the test adhesive tape was inserted, using a double adhesive tape, into a metallic rail (350×40 mm) of an electronically-controlled tearing machine fixed in place with a lower tension clamp. A stiff, approximately 400-mm long film strip was attached to the test adhesive tape and fixed in place on the tearing machine with an upper tension clamp. The test adhesive tape was then pulled off at an angle of 180° and with a pulling-off speed of 1800 mm/min. A force diagram recorded the release force determined to remove the sample strip. In each case, an average of 3 measures were calculated.

2. Determination of Adhesion of the Coating to the External Layer

26. The adhesion of the coating to the external layer of a tubular film according to the invention was tested as follows: A tubular film sample was placed on a smooth base so that the coating points upward. Then, a finger was used to rub vigorously four to five times over the surface of the coating. The adhesion of the coating to the external layer was assessed as follows:

Test OK (test all right) = no partial (or full) detachment of the coating;

Rub-off = partial (or full) detachment of the coating.

3. Testing Methods & Instruments for Friction, Air Inflation Test, Splicing and Break

27. To determine the elasticity of the comparative example film V1 and of the various multilayered films according to the invention shaped like tubular films (i.e., examples B1-B6), air inflation tests were carried out.
28. As preparation, a 5 m long tubular film with a tube circumference of 1175 mm to 1180 mm was hermetically sealed on both ends by two metal disks. To achieve an airtight seal, tension belts and commercially available woven cloth adhesive tape were used, which is customarily used in air inflation tests. Through a valve in one of the two metallic disks, pressurized air was fed into the tubular film until it burst. Before bursting, tears in the inner film layers (known as splices) were recognizable. From them, an exclusively localized bubble started forming in the multilayered film, which, as the air inflation process continued, developed into a tear in the tubular film that led to its bursting. The maximum elasticity value (expressed in percent) was determined by measuring the spot with the outermost circumference of the tubular film until it burst and comparing it with the initial tube diameter. The following formula was used:

$$\text{Maximum elasticity} = [(\text{tube diameter after inflation} / \text{initial tube diameter before inflation}) - 1] \times 100$$

29. A similar formula was applied for the “film splice,” i.e., the first recognizable tear of a layer of the tubular film (without affecting the entire tube):

$$\text{“Splice”} = [(\text{tube diameter after inflation and first recognizable layer tear} / \text{initial tube diameter before inflation}) - 1] \times 100$$

30. For the subsequent tests, the films were stored in a standard climate for 24 hrs. We used the BETEX Slipping Tester RK2 with a load cell of 10 N as the device to test for the sliding friction. A LINSEIS L120 E recorder was used to record the values. Two film pieces were stressed with a load (1.96 N), pulled on top of one another and the force needed for doing this was measured.

C. Materials Used

31. The following materials were used in conducting the experiments.
32. The portion of the experiments involving applying a coating of polysiloxane (so-called siliconization) to tubular film was carried out under the supervision Dr. Kurt Stark, a co-inventor of the ‘882 patent. The following materials were used for the siliconization.

TEGO® photoinitiator A 18 is a photoinitiator (concentration for use: 1.5-2%) for curing TEGO® RC silicones through UV rays.

TEGO® RC 702 is a solvent-free, UV cross-linkable (curable) silicon acrylate for the manufacturing coatings with low release values.

TEGO® RC 711 is a solvent-free silicon acrylate for the release coating of paper and plastic films. It serves as an adhesive promoter and component to increase the release value together with other TEGO® RC silicones. TEGO® RC 711 is a CR (controlled release) additive and adhesive promoter that has a linear structure with more than 10 but less than 20 Si units. The RC value is 0.62, density 1 g/cm³ and viscosity 400-700 mPas at 25° C.

TEGO® RC 902 is a solvent-free silicon acrylate for coating paper and plastic films, and is used for achieving low release values. TEGO® RC 902 is a base polymer with initially one spacer (≥ 3 C atoms), and then an acrylate group. It has a linear, bifunctional structure (α, β), its RC value is 0.91, density 1 g/cm³ and viscosity 200-600 mPas at 25° C.

All the TEGO products named above were obtained from Evonik Industries AG Co. The RC value indicates the proportion of polysiloxane, whereas the remaining components are of organic origin (i.e., the acrylate groups). For example, an RC value of 0.91 of TEGO® RC 902 means that it contains 9% organic materials and 91% polysiloxane.

33. In the examples presented below (B1-B3) and in the comparative example (V1), a mixture of 12% Durethan B40 FAM (Lanxess), which is a PA 6, and of 88% Durethan C38 F (Lanxess), a medium-viscosity copolyamide, was used for the external polyamide layer.

34. The adhesive promoter used was Admer NF498E, an LDPE modified with maleic anhydride (MAH) groups commercially available from the Mitsui Co. Admer® substances are PE copolymers with maleic anhydride groups that adhere strongly to PET, EVOH and PA, and can be processed very well and are as thermally stable as normal PE.
35. The polyolefins used in the experiments were Lupolen 2420 F, an LDPE available from the LyondellBasell Polymers Co., and Exceed 1327 CA. Exceed 1327 CA is available from the ExxonMobil Chemical Company and is an ethylene copolymer manufactured using metallocene catalysis, in which another co-monomer is used in its polymerization apart from ethylene hexene.
36. The adhesives used were TESA 7476, a rubber-based adhesive, and TESA 7475, an acrylate-based adhesive. The (release) wax Constab PE-SA 270 made with ethylene bis stearamide (EBS) wax available from CONSTAB Polyolefin Additives GmbH was used as a migrating lipophilic compound.

D. Manufacture of Tubular Films

37. The film of comparative example V1 is a 200-µm thick tubular film without a releasing coating or covering (i.e., release finishing), and without wax additivation used as an inner tubular film in trenchless sewage pipe renovation. Comparative example V1 uses Durethan C38 F (88%) and Durethan B40

FAM (12%) as the external layer. Durethan C38 F is a PA 6.66 polyamide with no additives, while Durethan B40 FAM is a PA 6 polyamide with a slip agent incorporated therein. The amount of slip agent (migrating compound) contained in the Durethan B40 FAM was less than 0.1% (1,000 ppm). Thus, the external layer of comparative example V1 contained less than .012% slip agent (120 ppm). The less than 120 ppm of migrating compound in the external polyamide layer of comparative example V1 without wax additivition was insufficient to migrate to the surface and to form a covering. Comparative example V1 includes the following materials:

Layer number	Composition	Proportion in layer in %	Thickness in μm
1	Durethan C38 F	88	40
	Durethan B40 FAM	12	
2	Adhesive promoter: Admer NF 498 E	100	10
3	Lupolen 2420 F	70	65
	Exceed 1327 CA	30	
4	Adhesive promoter: Admer NF 498 E	100	10
5	Lupolen 2420 F	70	75
	Exceed 1327 CA	30	
			Sum: 200 μm

38. In examples B1-B3, the polyamide side of the film from comparative example V1 was coated (finished) with the following silicone or polysiloxane formulations:

Example B1: Comparative example V1 plus polysiloxane formulation 1 according to the following table (application weight AW: 1 g/m²) that allows an easy release and has an especially good release effect;

Example B2: Comparative example V1 plus polysiloxane formulation 2 according to the following table (AW: 1 g/m²) that allows a tight or controlled release and has a medium release effect;

Example B3: Comparative example V1 plus polysiloxane formulation 3 according to the following table (AW: 1 g/m²) that allows a medium release and has a good release effect.

Example	Evonik RC products Quantities in % by weight			
	RC902	RC702	RC 711	A 18
B1		100%		
B2			98%	2%
B3	59%		39%	2%

39. A person having ordinary skill in this art is familiar with suitable coating equipment, which include a 5-roller coating machine, for example. After the polysiloxane coating of examples B1-B3 is applied, it is UV cured.
40. For tubular films with additional wax added as a migrating material to form the covering over the external layer, the following samples B4-B6 were prepared.

41. Example B4: Structure of the inner tube film: thickness 200 μm ; with 1% Constab PE-SA 270 containing the release wax (migrating additive) ethylene bis stearamide (EBS) in the polyamide external layer:

Layer number	Composition	Proportion in layer in %	Thickness in μm
1	Durethan C38 F	87.5	40
	Durethan B40 FAM	11.5	
	Constab PE-SA 270	1.0	
2	Adhesive promoter: Admer NF 498 E	100	10
3	Lupolen 2420 F	70	65
	Exceed 1327 CA	30	
4	Adhesive promoter: Admer NF 498 E	100	10
5	Lupolen 2420 F	70	75
	Exceed 1327 CA	30	
			Sum: 200 μm

42. Example B5: Structure of the inner tube film: thickness 200 μm ; with 4% Constab PE-SA 270 containing the release wax ethylene bis stearamide (EBS) in the polyamide external layer:

Layer number	Composition	Proportion in layer in %	Thickness in μm
1	Durethan C38 F	85.5	40
	Durethan B40 FAM	9.5	
	Constab PE-SA 270	4.0	
2	Adhesive promoter: Admer NF 498 E	100	10
3	Lupolen 2420 F	70	65
	Exceed 1327 CA	30	
4	Adhesive promoter: Admer NF 498 E	100	10
5	Lupolen 2420 F	70	75
	Exceed 1327 CA	30	
			Sum: 200 μm

43. Example B6: Structure of the inner tube film: thickness 200 μm ; with 6%

Constab PE-SA 270 containing the release wax ethylene bis stearamide (EBS)

in the polyamide external layer:

Layer number	Composition	Proportion in layer in %	Thickness in μm
1	Durethan C38 F	85.0	40
	Durethan B40 FAM	9.0	
	Constab PE-SA 270	6.0	
2	Adhesive promoter: Admer NF 498 E	100	10
3	Lupolen 2420 F	70	65
	Exceed 1327 CA	30	
4	Adhesive promoter: Admer NF 498 E	100	10
5	Lupolen 2420 F	70	75
	Exceed 1327 CA	30	
			Sum: 200 μm

E. Results

1) Determination of Release Force/Adhesion

44. The release force necessary for removing the release film from a test adhesive tape in all release films of examples B1-B6 and of comparative example V1 was determined with the method described above. The following results were obtained:

Example	Release force in cN/25 mm (tube front/back side)			
	Adhesive TESA 7476 (simulates resin's stickiness)		Adhesive TESA 7475	
	1 d, 40° C.	7 d, 40° C.	1 d, 40° C.	7 d, 40° C.
V1	blocked	blocked	798/772	796/745
	Films with polysiloxane coating (silicon)			
B1	55/45	52/49	8/8	9/9
B2	402/391	415/398	130/128	112/123
B3	60/44	76/62	9/7	12/10
	Films with wax additivation			
B4	753/752	734/736	823/623	615/610
B5	420/419	415/417	297/299	290/291
B6	405/404	401/405	278/279	275/275

The release force for B4 with adhesive TESA 7475 after one day was 623/623 cN, as indicated in the German priority application and in the first English version of the specification in the file history. The 823/623 cN listed in the table above is a typographical error (823 should be 623).

45. In the tubular films of examples B1-B6, the front and back side (or the upper and lower side) of the tube laid flat are in each case identical with regard to the coating or covering with migrating additives. The side that has the coating always faces outward in the tube. The values measured for the front side of

the tube's external side and for the back side of the tube's external side are identical within the scope of measurement accuracy. The stickiness of the resins typically used in pipe lining is largely the same as the stickiness of TESA 7476 (rubber-based adhesive) and can be estimated very well with it.

46. As can be seen in the table above, the polysiloxane formulations of examples B1 and B3 have almost similar release force values, although the easy release polysiloxane formulation from example B1 has somewhat lower values than the medium release formulation of example B3. However, in the two adhesives tested, considerably higher release forces are found in the tight release polysiloxane formulation of example B2.
47. Regarding the TESA 7476 adhesive with properties similar to resin, a release force range from approx. 20 cN/25 mm to approx. 550 cN/25 mm is possible by selecting the corresponding formulation for the polysiloxane coating. Therefore, the release behavior of the inner tube film, i.e., its external side, can be adjusted within a very wide range from the resin after it has been cured, going from especially “easy removal” and “moderate removal” all the way to “difficult removal”. Even when the tubular films according to the invention are used as sliding films or preliner films, the reduction of the release forces is very beneficial for the application, as this is also accompanied by a lowering of the coefficient of friction (COF) and resin adhesion is therefore prevented.

48. A reduction of the release forces is also seen in the tubular films according to the invention B4-B6. Compared to the film from comparative example V1, this causes the prevention of the blocking (i.e., an undesirably strong sticking against one another coupled with impossible separation) of the film with the rubber-adhesive TESA 7476 and measurable and considerably lower release forces are achieved with 753 cN/25 mm, 420 cN/25 mm and 405 cN/25 mm (values after 1 day (1 d) and 40° C storage). The same trend is achieved with the acrylate-based adhesive TESA 7475. Compared to the film from comparative example V1, the initial value of 798 cN/25 mm therefore decreases to 623 cN/25 mm if 1% PE-SA 270 is added to the polyamide layer (example B4). With 4% PE-SA-270 in the polyamide layer, a release force of 297 cN/25 mm was determined (example B5); the continued increase of the concentration to 6% PE-SA 270 led to a release force of 278 cN/25 mm (example B6).
49. Although additivation with wax (release wax) in both adhesives does not quite reach the low release force level of a coating of the film with polysiloxane (B1-B3), a marked reduction of the release force and the friction values is nonetheless achieved. Consequently, the release force level—which can be adjusted when polysiloxane coatings are used in the approximate range of 20 to 550 cN/25 mm and can be expanded up to about 800 cN/25 mm, i.e., until

the film starts blocking against the adhesive or resin, which allows an even broader application area of the films according to the invention, particularly when tube liners are manufactured or in the pipe lining process in trenchless sewage pipe renovation.

2. Determination of Adhesion

50. The adhesion of the coating to the external layer of the tubular films B1-B3 in question was tested with the method described above, and the results are tabulated below:

Example	Adhesion of the coating to the external layer
V1	(not available, OK)
B1	Test OK
B2	Test OK
B3	Test OK
B4	(not available, OK)
B5	(not available, OK)
B6	(not available, OK)

Test OK = Test is all right (no rub-off effect)

51. The table shows that, after UV curing, the polysiloxane coating from examples B1-B3 is firmly anchored to the film and cannot be rubbed off. This is especially important when the tubular film according to the invention is used as inner tube film in trenchless sewage pipe renovation because if there is insufficient bonding, residual polysiloxane could migrate into the resin and have a negative effect on its curing as a result of this.

52. Since the films from comparative example V1 and those from examples B4-B6 have no polysiloxane-based coating, no rub-off effect can occur there. Thus, the curing of the resin is neither affected by the coating of the tubular film with polysiloxane nor by the addition of components migrating to the surface, where they cover it with a thin layer.

3. Determination of the Coefficients of Friction (DIN ISO 8295)

53. The following coefficients of friction (COF) were measured in the tubular films of comparative example V1 and of examples B1-B6, where one external side of one film was measured against the one of another film:

Comparative example V1: mean 0.31; PA side vs. PA side;

Example B1: mean 0.25; polysiloxane-coated sides against one another;

Example B2: mean 0.27; polysiloxane-coated sides against one another;

Example B3: mean 0.245; polysiloxane-coated sides against one another;

Example B4: mean 0.24; wax-additivated sides against one another;

Example B5: mean 0.16; wax-additivated sides against one another;

Example B6: mean 0.14; wax-additivated sides against one another.

54. It is immediately obvious from these results that both a coating with polysiloxane (so-called siliconization) and an additivation with substances migrating to the surface reduce the coefficient of friction COF. It is in trenchless sewage pipe renovation where low COFs are always advantageous, as then the tube liners can be more easily drawn into the pipe.

4. Air Inflation Test, Splicing and Break

55. The results of the Air Inflation Test, splicing, and break are provided in the table below:

Example	Initial circumference in mm	Splice in mm	Splice in %	Break in mm	Break in %
V1	1054	1222	15.9	1902	80.5
B1	1044	1220	17.9	2050	96.4
B2	1042	1280	22.8	2170	108.3
B3	1050	1250	19.0	2100	100.0
B4	1050	1229	17.0	1985	89.0
B5	1052	1245	18.3	2016	91.6
B6	1050	1243	18.4	2025	92.9

56. A surprising finding was that the elasticity until break increased significantly with coating with polysiloxane and wax additivation compared to the non-siliconized reference that was not additivated with wax from comparative example V1. In the polysiloxane-coated tubular film from example B3, the increase in elasticity until splice compared to the reference from comparative example V1 is 3.1%, in example B2 even almost 7%.

57. Another clear improvement is also seen in the elasticity until break. Whereas comparative example V1 breaks already under an elongation of 80.5%, the polysiloxane-coated tubular film from example B1 can elongate 96.4% (15.9% more than V1), and in the case of the polysiloxane-coated tubular film from example B3 the elongation is 100.0% (19.5% more than the reference V1). The improvement of the elongation until break becomes clearest in the tubular film coated with polysiloxane from example B2, where the elongation until break is 108.3%—even 27.8% greater compared to the reference V1.
58. Additivation with wax also causes a noticeable increase in tubular film elasticity until film splice and film break, as the comparison of examples B4-B6 with the non-additivated film from comparative example V1 shows. Anyhow, the addition of 6% wax (example B6) increases elasticity until film splice by up to 2.5% compared to the film from comparative example V1. Film elongation until break improves by more than 12% in the film of example B6 compared to the film from comparative example V1 (in example 4: 8.5%, in example 5: 11.1%). Siliconization in both sides of a tubular film (laid flat) significantly increases elasticity until splicing or break. Additivation with wax leads to noticeable improvements too.
59. A possible cause for this surprising and positive effect with regard to the mechanical properties of the tubular film according to the invention can be an

additional protective effect of the external polyamide layer owing to a thin polysiloxane film (due to coating) and also to a thin covering with wax (covering due to migration to the surface). The two variants—coating with a polysiloxane (“siliconization”) and wax additivation—lead to a hydrophobic, water-repellent protective layer on the external side of the tubular film.

I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: June 24, 2024 in Siegenburg, Germany

By:


Abdel-Kader Boutrid