Sealants.

Photo: The average sealant aisle in a big home improvement store. What sealant should I choose? The answer is none of them, most likely. Get a professional sealant instead – it typically would cost almost the same, but the results would amaze you.

Introduction. How an average homeowner, a handyman, or a small contractor could pick the right sealant and use it properly? You cannot expect him or her to spend days doing her research online. I often see customers staring at sealant aisle in home improvement stores and picking e.g. the least or the most expensive sealant they find, or asking a shop assistant for advice. More likely than not, most stuff found in big box stores is not going to cut it, whatever it is that you are doing, and we would give you the tools to read the "nutrition label," so you could figure it out yourself. The same reliance on seller's advice is seen in dedicated contractor supply stores, which should offer a better advice, at least in theory. Unfortunately, based on our experience, your results may vary, and asking the seller seldom is going to work. The next challenge is the proper application, which, even by professional sealant contractors, is seldom seen, based on our experience from many large projects. Here, the rules are simpler in theory, but much harder to apply in the real life. We would at least point you to the right sources.

Sealant Materials. There are many different sealants out there, but we would focus only on three types: 1) silicones, 2) polyurethanes, 3) butyls, and only mention some other types in passing. There are several properties that you would most likely need: UV resistance, good adhesion, elasticity and more generally resistance to mechanical abuse. In some cases, you may need more, such as ability to survive submerged in water, paintability, staining resistance, etc. and we will address them too.

Sealant Properties. Here are the general properties, explained deeper, and a word of caution: is in order first: not all sealants that are made of certain material are alike, there are significant differences that come to light once you read their spec sheets. For example:

1) UV Resistance. This property would interest you in exterior applications, generally speaking. **Silicone sealants** are unsurpassed in this department. Their adhesion varies, so it needs to be tested first with and without primers. Once tested, they are also so good at bonding that they could be used as a serious "structural" adhesive (they could replace mechanical fasteners). Not surprisingly, exterior joints are generally best made with silicones; polyurethanes' UV resistance is generally worse than silicones, but they generally bond to more typical exterior materials and finishes, including poorer-prepared substrates, which makes them the second choice seen in exterior applications.

2) Adhesion. Strength and durability of attachment is often more important than the durability of the material itself, particularly given the realities of the average job site: poorly prepared and varied substrate for sealant application. **Polyurethanes** are unsurpassed in this department; this is why they are often used as a glue, (although some polyurethane application would still require a primer). **Butyls** offer very broad adhesion range, and they tend to protect their bonds better against mechanical stresses. **Silicones** generally have two blind spots among substrates: concrete and some plastics, otherwise they generally bond very well, providing the surfaces are well-prepared, which makes them the first choice in glazing applications, particularly those shop-glazed. Btw. Applicators are normally expected to test the adhesion first, before proceeding with the entire project.

3) Elasticity and general resistance to stress require either a good professional-grade **silicone** sealant, or a **butyl** sealant, as we would explain further. However, high compressive strength aplications, e.g. traffic sealants are best entrusted to **polyurethanes**. **Acrylic sealants** quickly loose elasticity and shrink. The design of a joint is of significance, e.g. most applications require that both sides of any joint should be given at least ¼" wide "grab "to the substrate, separated by at least ½" of "loose" sealant material that should be maximum ½" deep, in order to accommodate differential movements. It explains why fillet joints are typically bond to fail prematurely: obtaining such a separation requires a bond breaker in the middle. Controlling proportions of the straight sealant joint requires use of a backer rod. These indispensable partners of sealants appeared on supermarket shelfs only recently, making one wonder how sealants were ever done properly before. Good sealant manufacturers publish free technical manuals explaining complexities of applications – sources are listed at the end of this paper.

4) Paintability is typically associated with **acrylic latex**, (you can attempt to paint over silicone and urethane sealant beads if you use a thin paint spray first to build a dry skin over them; but the results don't last very long though), however **acrylic latex** is prone to shrinkage, and weathers poorly. **Butyl** is

also paintable. Non-paintable sealants are offered in varieties of colors precisely for this reason, the full palette of which is normally available only as a special order, requiring thinking ahead.

5) Submersion. Submerged waterproofing materials generally deteriorate quickly, which is why positive slopes are so important in design and execution. Sealants dedicated to applications submerged by liquids, such as water (and fuel if you also happen to be in need to seal your fuel tank) are **polysulfides**. These are often two-part applications that require mixing before application.

6) **Non-Staining**. Porous substrates may stain badly in contact with sealants. Some very expensive stone-clad building facades all over the world were sadly ruined by sealant migrating and staining the stone. The only way to determine is to test it. To narrow the choice, look for pre-tested sealants dedicated to certain common substrates. A proprietary non-staining sealant specifically formulated for this function is typically tested thrice: first when the sealant is developed for the market, then for the specific material samples in the laboratory months before construction, and finally on the job several weeks before work begins in the field.

WHY. So now, if you are like the solar rooftop installer whom I recently saw with a tube of silicone sealant trying to seal holes he just drilled through the roofing, your first question is "*is it going to work on this substrate?*" The good news for contractors and material suppliersis that any sealant random picked from the shelf would almost always work long enough for them to collect your paycheck. The bad news for the owners and occupants is not for long enough to be considered fit for its use. Here is why, generally speaking:

1) Most sealants prematurely fail adhesively. It happens for several reasons: a) incompatible substrate, b) badly prepared substrate, or otherwise inadequately installed, e.g., not tooled. Both could be improved by testing prior to application, as we will explain further. There is unfortunately a very large subcategory of poorly-designed joints offering too narrow grabbing surface, such as most window flanges on the market, and these seldom can be improved, without resorting to redesign, often resulting in something completely different, e.g. terminating bars grabbing skirts made of waterproofing membranes adhered onto adjacent surfaces at perimeters of openings, often dispensing off sealant joints altogether. Adhesive failure is an effect of mechanical stress, inherent in every sealant joint, and described below.
2) The second most populous group are sealants that fail prematurely due to mechanical abuse. The best example is your metal coping or gutter flashing: it expands and contracts thermally, shearing badly designed sealant joints. E.g. A 10-ft section of aluminum profile would normally be expected to move at least 3/16", while you would see it often addressed by a ½" band of sealant that has no way to stretch that much. The head joint of your window wall could sometimes expect 3/4" or more of differential movement resulting from structural floor slab movements, while it's typically only ½" wide. It could be that the sealant was chosen with excessive elastic modulus (too stiff). Some of these sealant joints were poorly installed, e.g. the backer rod was pushed too deep creating too rigid a section to allow for elastic deformation. Best sealants on the market could stretch or compress maximum twice, generally speaking (we will explain how to tell them in the moment), so if you see a sealant section that is less than twice as wide as the expected movement, you may need to stop what you are doing and rethink the design. Most of moving sealant joints

are designed to fail, simply by giving them too little space to move, while not controlling the range of movements, and in most of those cases, you'd need a completely different solution, e.g. EPDM or silicone tapes, as mentioned before.

3) Few joints that remain after strained through those two categories listed above would fail cohesively due to aging or other, more exotic reasons. This is so infrequently seen, that you probably don't really need to worry about that at this early procurement stage. In the former case, by then you'd already got your money's worth, in the latter case, it's typically the manufacturer who would foot the bill for a defective product. Generally speaking, if you see alligatoring (one of typical tell-tale signs of aging) of otherwise sound sealant, it means that was a good application, where replacement with silicon could prolong its life.

You may be justified to suspect reading the above list that *the choice of material is actually secondary to most of your future troubles, statistically speaking*. True, it's a *prerequisite* instead: items 1 and 2 above can often be remedied by choosing a low modulus of elasticity that would protect the weak adhesion from overstrain and failure. First low modulus sealants appeared in large box stores only after I started typing this, making one wonder how anyone shopping there before was able to get their job last.

Preparation. Based on the list above, you will need to focus on *3 primary challenges*: preparing the substrate, testing and getting the right sealant, and installing it right. We will talk about it next.

Preparing the substrate. This is one of few things that manufacturers won't tell you how to do right: most of them simply ask you to clean with alcohol or MEK solvents, keep it dry, above freezing, use two clothes, etc. Most of contractors ignore these nagging messages anyway, but even if they do, these instructions seldom work. The right cleaning method depends on circumstances. Your typical surface would normally be covered with invisible film of miscellaneous substances, ranging from oil to soaps, and including everything in-between such as paint overspray, and oxides (corrosion). Good luck removing it with alcohol or MEK, regardless of number of clothes. Oils would normally only be diluted with solvents, so what you really need is e.g. a strong bleach, (but be wary of those substrates that bleach could corrode, such as aluminum) in order to remove it chemically. Soaps and corrosion could be removed with strong acids, but these would corrode almost everything else and eat grout and mortar, as you probably already discovered cleaning a soap scum off typical ceramic tiles in a bathroom. Corroded metals, as well as some porous materials such as concrete, and masonry would be best sandblasted, otherwise the corrosion would return and create a bypass (frequently seen e.g. on pipe stacks on roofs and guard posts on balconies and terraces, where pipe's surface corrosion allows moisture to successfully bypass the penetration's seal installed around it). If that doesn't sound challenging enough, you may recall how difficult it is to simply remove the previous, failed sealant bead off a substrate's surface: in most cases it requires mechanical scraping with steel blades, and metal brushes, risking scratching paint finishes, glass, ceramic, and many other surfaces. Most sealant materials could be chemically stripped, but it takes a long time, and is usually successful only when applied on a thin remaining layer, after the majority of sealant bead was removed mechanically. Strippers fall into several categories: either very caustic, or highly volatile, or ecologically slow and less effective. Read labels, read MSDS sheets, and protect yourself and others: no sealant job is worth risking anyone's health.

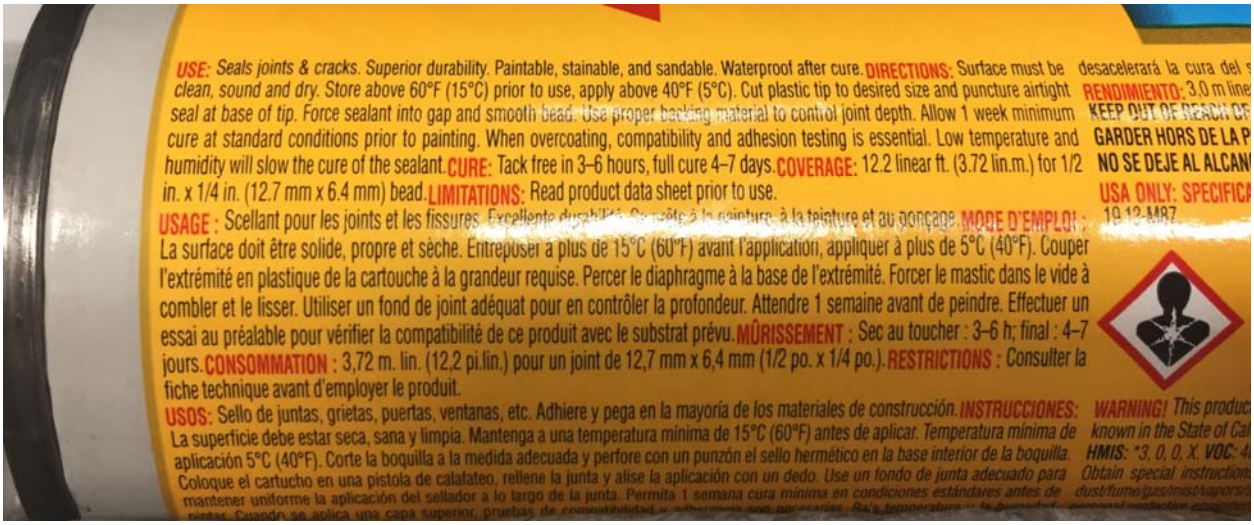

Photo. "Nutrition Label" on your typical sealant cartridge contains little information, and instead refers you to read the product data sheet. ***The most important information is missing here: what material it is.*** *(In this case we discovered that it's a urethane sealant, which generally means it probably bonds well to more substrates than other sealants combined.) It's fairly typical practice, and we could only guess that it's a marketing effort to prevent side-by-side comparison of their products. Much space on American labels is usually wasted on repetitive and mundane warnings: don't swallow, don't inhale, etc., because the chief concern here is to avoid liability. These are important considerations, but not at the cost of missing the elementary information about the product itself.*

Field adhesion test. Once the substrate is ready, you'd need to test it to get the right sealant. To save time, get several different sealants and either adhere small coupons of a well-adhering material (e.g. aluminum plates) to the tested substrate, or produce samples of the actual joint beads, maintaining the same sealant proportions, typically between ¼" to ½" both depth and thickness, and the same length: and let it cure. Once cured, severe the adhesion plane from the tested substrate with a steel blade, same length for each specimen, typically 6" long, and peel the sealant tail slowly off at a consistent angle. Pull the tail in whatever direction or manner that best avoids any cohesive tearing and encourages adhesive failure. If the sealant shows a tendency to tear cohesively at the tail, stop and readjust the grasp, trim away a tail section that was torn away, make a new tail, and begin pulling again. Finally, if the sealant fails by splitting within its depth (cohesively), it passed, otherwise if it fails at the adhesion line (adhesively) it failed. A good sample would consist of several specimens for each type of sealant, and uniform and consistent approach is the key for reliable comparison. Such a testing could be further divided by applying primers onto some areas of the substrate prior to sealant application to compare not only sealants but also primers. Details of such standardized testing procedure could be found in AST C1521.

Getting the Right Sealant. Sealants talk to me, so let me teach you their language. The typical nutrition label is just the introduction, so you'll need the specification sheet. Most information is repetitive, and directed to the least experienced and least knowledgeable, e.g. don't eat it, don't put it in

your eyes, don't install around and below freezing temperatures, use proper backing materials to control the proportions of the section, etc. These are important instructions if you are a rookie, but generally unhelpful in the task that we are describing here: comparing products and selecting, the right one for your specific application. Let's focus on the differences instead.

Expiration Date. There is a good reason to care: sealants expire quickly, in a matter of months. I recently lost a very expensive week working on a deadline in a faraway, flown location, because the roofing supply store sold me a case of expired sealant, at first refusing to answer my question about the expiration date, when I discovered there was none marked on sealant cartridges after the sealant (STS GreatSeal PE-150) was released to me from their warehouse. Cartridges seemed soft enough, and my cab was waiting, while the weather was coming, so I rushed on the job site to install it. Although they later provided me with another (also unmarked) case free of charge, the cost of the second thousand miles trip, expensive cleanup of the mess, and almost missing the deadline far surpassed the meager cost of the material itself. This is a very common situation that illustrates several important points:

1) warranties are generally useless,

2) some manufacturers no longer show expiration or production dates on packaging.

3) consistency of sealant is not a reliable indicator of its ability to bond.

Sadly, it also illustrates how clueless the sealant consumers are: for comparison, imagine a similar situation if it happened in a grocery store "*We are so sorry to hear that your son's bill from an emergency room is so high, but all we could do is we will cheerfully provide you with a complimentary can of the same product, free of charge. No, this one doesn't show the expiration date either…"* This situation probably deserves a class action to rectify. This was an exotic sealant, the very first that showed bond to the PVC roofing membrane that I was trying to seal, after over ten different sealant types that I tested before failed one after another, causing me to almost run out of time in the first place, so I didn't have much choice. You, on the other hand may. Whenever placing an order for sealant, make a note to the merchant: "*the sealant must have expiration date clearly displayed and no longer than six months in the future*," so you could later invoke this requirement. This simple note often saved me from getting old stock.

Another, related issue is how you store the sealant. Generally, the customers could buy one-part sealant in forms of foil-packed sausages (600 ml) and plastic tube cartridges (300 ml). While it may sound wasteful to buy twice as much sealant, sausages much better protect sealant, and generally last longer. They are a much better choice for those sealants that have long expiration dates, e.g. butyl. Sealants age primarily due to exposure; therefore, it pays to pack them tightly in multiple plastic bags, leaving as little air as possible, or even using a vacuum to such air off. Heat is generally harmful, so they are best stored in cool locations. Once opened, there are multiple tricks how to plug their nozzles, some manufacturers provide plungers or caps, contractors plug nozzles with fasteners, seal them with plastic bags. I typically also wrap them with an inverted rubber glove, when I pull it off my hand, as I often apply sealants in disposable rubber gloves, using my finger as an applicator.

Photo. Look for an expiration date on packaging. Refuse to buy any sealant that doesn't have it displayed. It's often printed either on the plunger lid, or on one of rims.

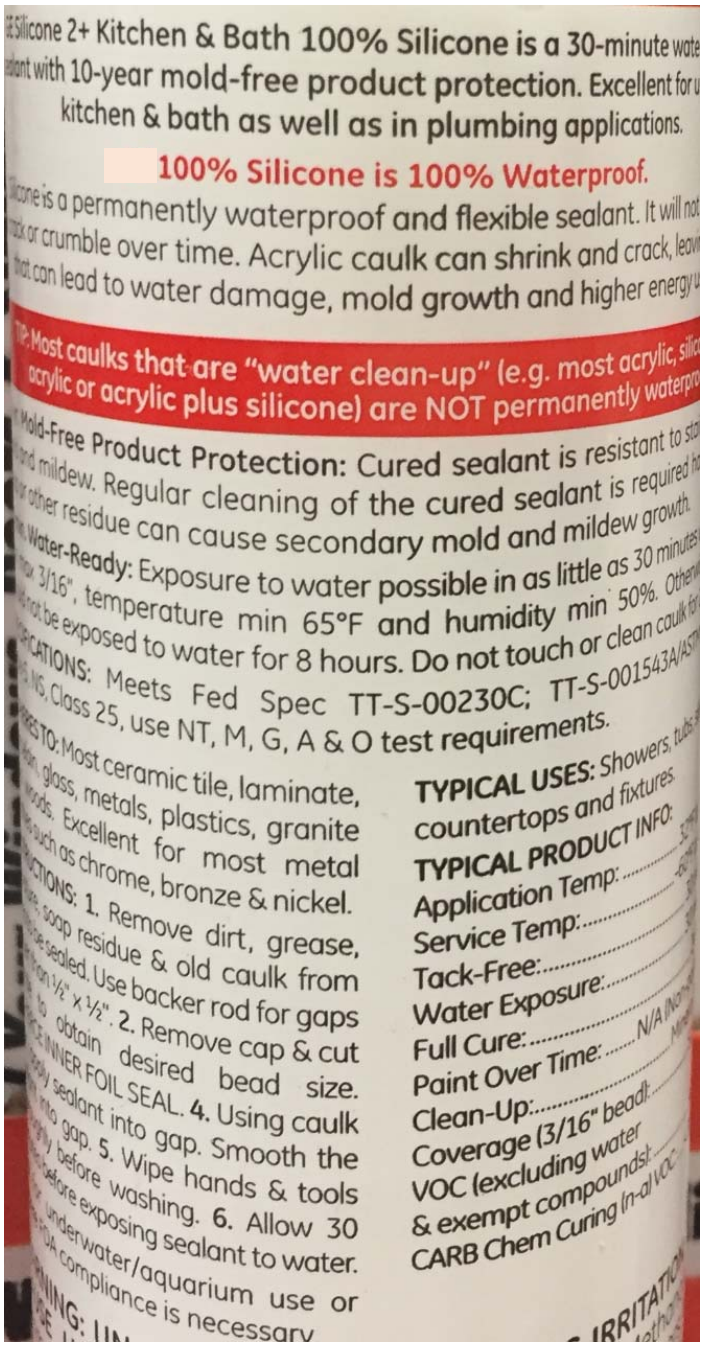

Photo. Look at the text emphasized with red color. Since this label focuses on blaming other products, the implied assumption would be that this product is free of these problems. It focuses on adjective "waterproof" misleadingly enough. No sane individual would expect any sealant on earth to remain PERMANENTLY waterproof, so it's just a marketing drivel. The important information starts with the word SPECIFICATIONS, and consists of hard facts: results of unbiased tests. This information is encoded in strange letters and number, in order to confuse a consumer. We offer a key to decipher it, see below.

Reading the Label. We offer some advice, as follows:

1) Much product information out there is intended to disorient a prospective buyer. Therefore, the first order of business is to disregard anything that a merchant is telling you, or at least take it with a grain of salt. E.g., I was recently getting a sealant advertised for concrete, and only after reading the specification sheet, I discovered that manufacturer does not recommend concrete substrate. I bought it anyway, as I will test it myself anyway, and if it doesn't work, I will use it for another application.

2) The second order of business is to cut the marketing obscuring facts. The label shown above is a good example: it disparages other products, while misleadingly focusing on adjective "waterproof," (which we did not find any authoritative definition of, when challenged on some projects, so it's fairly meaningless, explaining its use in fringe advertising). (All generally-marketed construction sealants are waterproof, because their primary function is typically to seal water, while silicone sealants are water-vapor permeable, so it could be argued that silicone is the least water-proof sealant material out there, because moisture could migrate through it.) Nothing on earth, much less sealant, is *permanently* waterproof anyway, whatever it may mean, because the nature of material things is that they disintegrate, it's the called *law of entropy*. Also, the misleading marketing doesn't end here: Its MSDS sheet shows some of its components proving that the bold claim "100% silicone" is not true, but no pure silicone sealant exists on the market to my knowledge. Some other manufacturers also use such a marketing strategy, but at least one accompanies expressions such as "Pure Silicone" and "100%" with either qualifiers or registered-name signs, indicating that these claims should not be taken at their face value. It does not indicate the base resin content; it just tries to separate its product from marketing gimmicks of latex and other sealant manufacturers who recently started using word "silicone" in their descriptions. Besides, quoting Petrie "*For most premium sealants, the polymer content is in the 30–50% range. However, there are perfectly adequate sealants at considerably lower solids content and lower cost. It is for this reason that one should develop functional performance specifications to best describe the end properties expected from the sealant."*

3) Cryptography. I need you to focus on what is hidden here: there is some information that starts with the word SPECIFICATIONS, and it consists of letters and number. This is what is really important in comparing different sealants, because those are results of unbiased tests, and the only way to objectively compare different sealants, within their narrow limitations. Class 25 is the movement capacity of the sealant expressed in percent: and my advice is generally don't buy anything that is less than 50 (meaning it could half-compress, and half stretch): see WHY point #2. (This is typically the reason #1, why typical consumer-grade sealants fail, and why this supposedly-permanent sealant failed adhesively in a matter of months, and I didn't care enough to file a claim to get my $8 back, which may explain why plenty of such products are still seen on market shelves.) This number typically is tied to how well the sealant adheres to substrates, because its adhesion failure that typically determined the limit of elasticity testing. Which is why this sealant separately advertises Class 35 for glass substrates, adding to the confusion (most sealants adhere best to glass, so it's not a real benchmark).

General thumb rule: don't buy any sealant below class 50, unless you really know what you are doing. *And this single advice would eliminate almost the entire stock of such a typical large home improvement store*

out of our consideration, until very recently. Silicone based products offer best movement capacity, and this threshold practically limits us to silicone sealants.

There are some unexplained letters:

Type S means it's a *single component sealant*, so you don't have to look for the "B" cartridge to mix it with an "A" component,

NT means *Non-Traffic* (you probably did not intend to walk on it anyway, but just in case),

I stands for *Immersible*,

Grade P means you it's *Pourable*,

NS means it *woN't Sag*,

M means it could adhere well to *Mortar*,

G means it could adhere well to *Glass*,

A means it could adhere well to *Aluminum*,

O means there were some *Other substrates* that tested well.

Here is the word of caution: treat the portion ADHERE TO with a grain of salt. E.g. stones, laminates, or plastics are seldom alike. There are material scientists who spend their entire professional life working with only one kind of stone or plastic. The chance that your limestone pool enclosure would be well served by a sealant previously tested successfully with someone's granite countertop is slim. Even the same stone type quarried from a single location could vary in properties. The good news is that good manufacturers have a list of previously-tested substrates that they share with their customers: it's typically there for asking, and could save you trouble testing some of the most troublesome substrates, such as weatherproofing membranes. Long-term chemical compatibility and staining are two types of tests that require time you may not have, and such information may save your time. (However, it's always best to plan ahead and simply send a sample of the substrate for testing to the sealant manufacturers months in advance.) Depending on circumstances, you won't even get charged for that.

Other information: Many labels may refer one way or another to VOC emission limits, which are seldom important for the average noncommercial user. Some may provide DON'T warnings: read them carefully. Few manufacturers would limit their market, unless it seriously burned their pocket.

Different standards. There are many competing testing standards, even within the U.S. Both TT-S-00230C, Type II and ASTM C920 Grade NS mean that this sealant was classified as non-sagging, which is just another way of saying that it won't try to escape from a ½" wide joint. See the label pictured below.

The variety available at the big box store is not worth addressing for one more reason: there is too much turnover. E.g. In the period I spent typing this paper, I was unable to find some sealant that I took photos of earlier, this is how fast they come and go. Invariably, there are some new sealants that try to solve the previous problems, e.g. paintable silicone sealants, and generally the new "hybrid" sealants, but ask yourself: how much successful track record could they have? Their manufacturers generally don't boast any, so we don't know. Tread with caution.

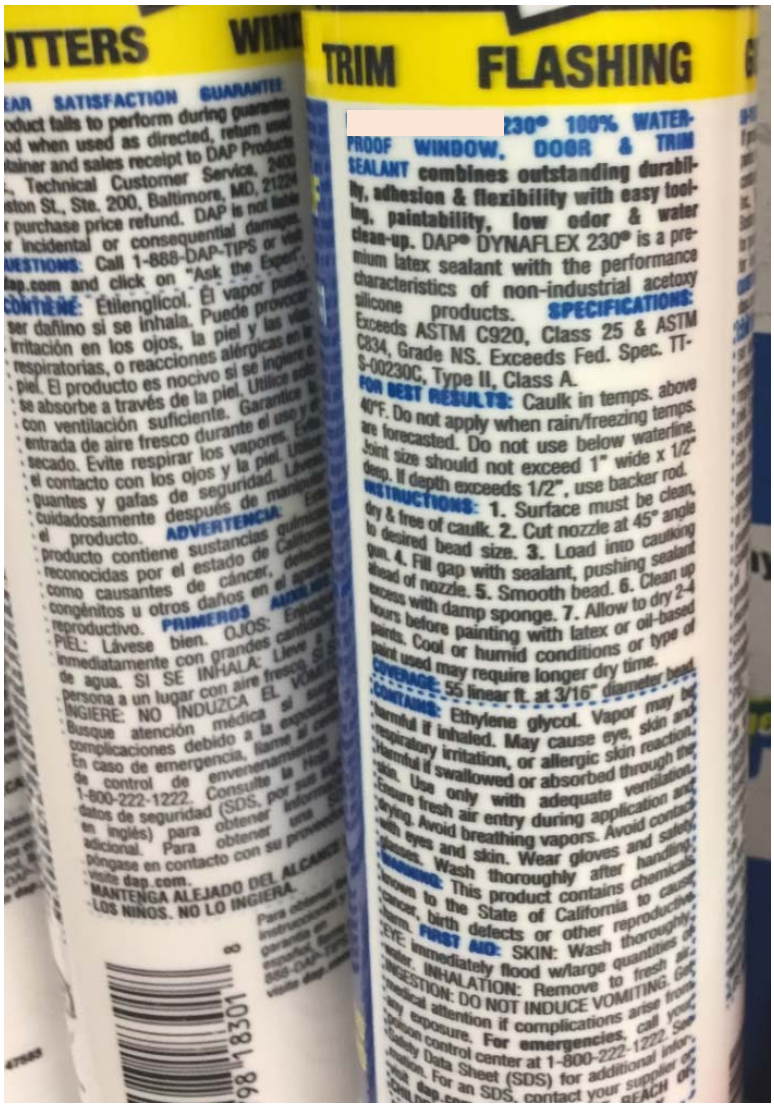

Photo. Here is a latex sealant that is advertised to be used on gutters and flashing, as well around windows, doors, siding, trim, and baseboards. However, its dynamic joint movement class is only 25, which means (poor) movement capability up to +/-25% so for a 1/8" movement, you would need at least ½" free span, with a backer-rod controlled depth, and with two ¼" adhesion widths adding up to a min. 1" wide joint, which is seldom achieved. Its primary benefit seems to be its paintability. It's best used on an interior trim and those cracks that are not expected to move at all, which is rare. These latex sealants contain chiefly powderized limestone. I use them only where I was planning to use a gypsum putty: it would crack a little less than gypsum. It comes with a lifetime durability guarantee, the trouble with all such warranties and guarantees is that they only cover the cost of material, which is very insignificant in comparison to other associated costs of failure. Hint: I tried many gutter sealants that were advertised as such, and they all failed in a matter of months. It must be either one of the most demanding applications out there, or those sealants don't work, or both. Both U.S. Both TT-S-00230C, Type II and ASTM C920 Grade NS mean that this sealant was classified as non-sagging. See also the next photo.

FAMILY HANDYMAN

Gutters: 100 Percent Waterproof

It's no surprise that a product designed to seal gutters needs to be 100

Photo copied from the unfortunate "Fine Handyman" article described later. This is yet another sealant that is advertised for gutters and flashing. It's a hybrid sealant, Class 25, with abysmal online rating on its products' manufacturer's website, to which the manufacturer responded with the boilerplate "…we're sorry to hear about your experience with our 3.0 Crystal Clear Premium Gutter and Flashing Sealant." Comes with a lifetime warranty, pretty safe considering that, most homeowners buy only a single $8 tube, not worth the trouble of filing a warranty claim, besides they'd often have displaced their store receipt by the next time they have the chance to examine their gutters. Buy at your own risk, as results may vary, and don't trust color magazines that cannot afford real professionals to write their content, and make their living on advertising construction materials and tools. Also, don't trust products that come with excessive warranties, e.g. "lifetime," trustworthy manufacturers are specific in their technical life expectations.

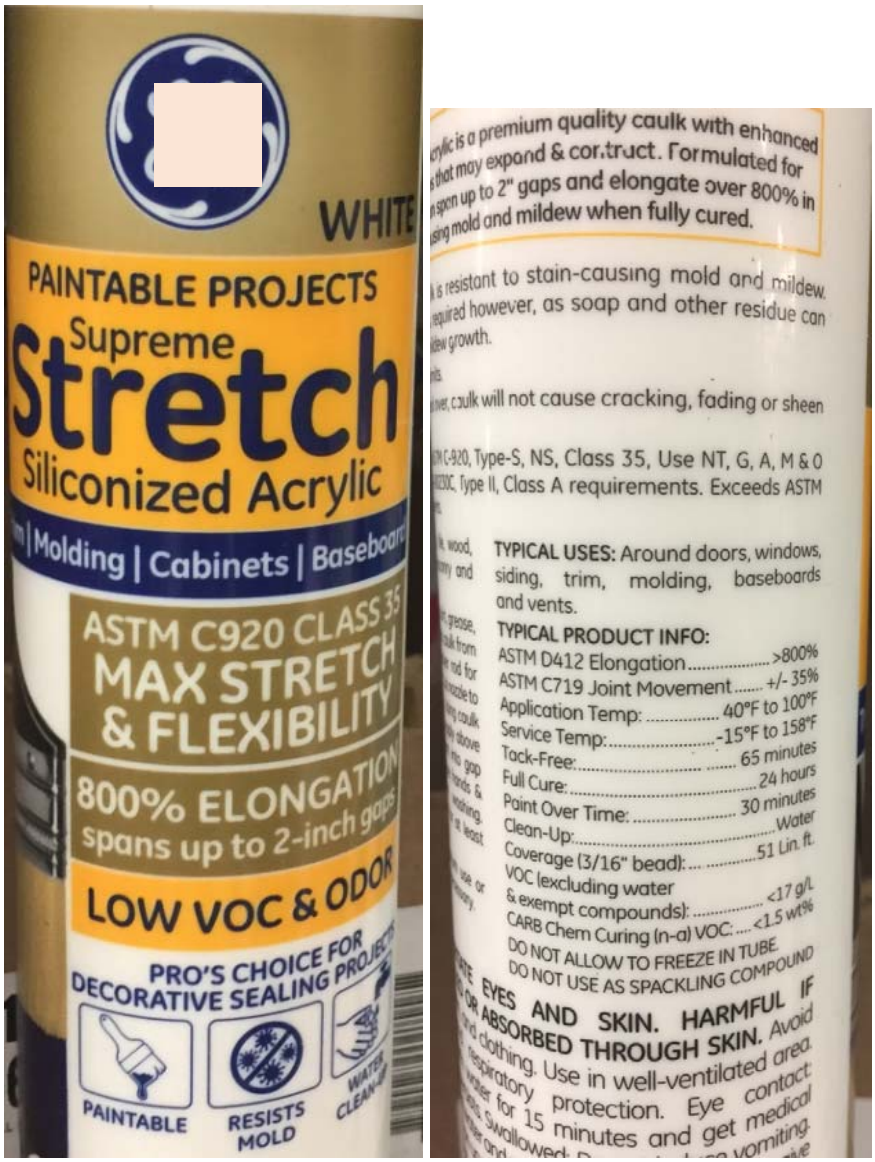

Photo. Here is a seemingly contradictory message: "ASTM C920 CLASS 35" means (relatively poor) movement capability up to +/-35% determined by the industry benchmark ASTM C920 testing procedure; which is confusingly combined with capitalized claim of "MAX STRETCH & FLEXIBILITY," and the label advertises 800% elongation and "supreme" stretch. Is there a typo somewhere? How is that even possible? The Class 35 under ASTM C920 means the maximum stretch and flexibility that this sealant ever accomplished when tested, (nothing to call home about), while the "800%" claim describes elongation measured under ASTM D412 (which standard hardly applies to such sealants, so its meaningless). Highlighting both claims made them look like they are benchmarked against competition. Another item of interest is the word "siliconized" in the descriptions, trespassing into silicone territory, prompting the dubious silicone sealant's claims such as "100% silicone," as described earlier. Interestingly enough, it's the same manufacturer.

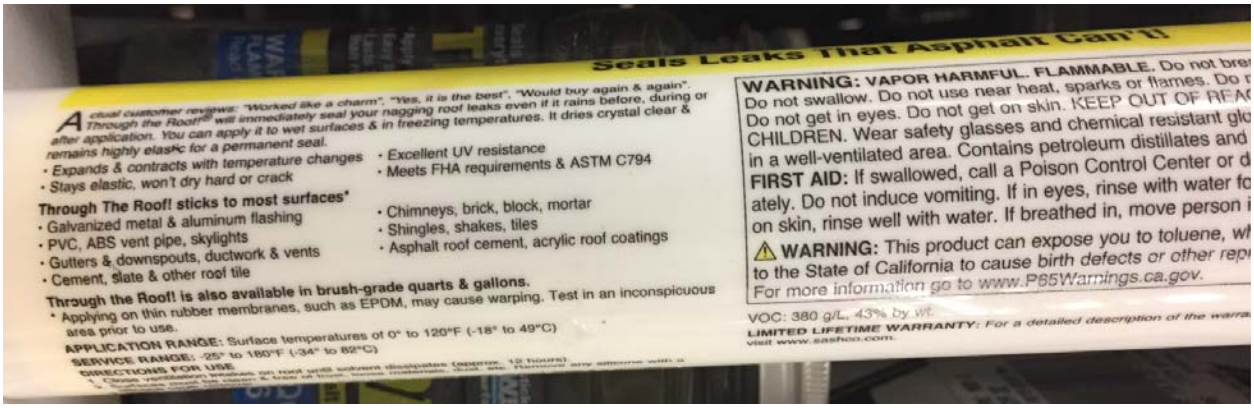

Photo. Label full of cryptic and meaningless claims: "Seals Leaks That Asphalt Can't!", "Meets FHA requirements & ASTM C794": We don't know what it means, as the two categories are too broad: FHA requirements may possibly refer to low VOC content (not clear why it would be applicable to a product intended for exterior roof applications), while ASTM C794, that provides a testing procedure for an adhesive force, is hardly a pass/fail standard. Typically, claims that a sealant "meets" or "exceeds standard" are meaningless, because standards typically describe testing procedures, as opposed to benchmarks; and they need to be clarified by performance-specific qualifiers, e.g. "exceeds ASTM C920, Class 25."

Most claims here are meaningless, such as "Expands & contracts with temperature changes" (show me a construction material that doesn't), "Stays elastic, won't dry hard or crack" (just give it enough time), and comparing a cold-applied sealant to asphalt is oranges to apples.

Accompanied with customer testimonials and a lifetime warranty. Don't trust products that come with excessive warranties, e.g. "lifetime," trustworthy manufacturers are specific in their technical life expectations.

Review of the specification sheet found no customary data such as e.g. ASTM C790 benchmark rating, that would allow for comparison with other sealants. Also, in spite of reading all the available literature, we still don't know what sealant it is, other than it's solvent based. Accordingly, it would invalidate your average SBS roofing warranty that is typically based on adherence to the technical manual that reads as follows: "No solvent-based materials or silicone materials."

Photo above: One of few products, that appeared recently in big box home improvement stores, that offer ASTM C790 Class 50.

ASTM C1382, and AAMAs are testing procedure, and hardly pass/fail standards, so these labels are meaningless here. Typically, claims that a sealant "meets" or "exceeds standard" are meaningless, because standards typically describe testing procedures, as opposed to benchmarks; and they need to be clarified by performance-specific qualifiers.

GREENGUARD Certification indicates it met VOC emission limits, which is fairly unimportant for an average noncommercial use.

Both TT-S-00230C, Type II and ASTM C920 Grade NS mean that this sealant was classified as a non-sagging, which is just another way of saying that it won't try to escape from a ½" wide joint.

Based on posted warnings, it appears to be a silicone sealant, but it's only a conjecture. The actual content of this product remains a mystery.

Planning Your Application. Most joints are not sealable in my experience, and there is very little that could be done to improve them, because they were just designed wrong from the scratch. A good example is a typical fillet joint between the average tub and the wall: it's a fillet joint, with the thickest portion of the bead expected to be the most elastic, while there is no depth left for the joint itself. One way to improve it would be adding a bond breaker: e.g. to tape the substrate in the middle with a bond breaking tape, e.g. vinyl tape commonly used by electricians. It would increase the depth of the section subjected to the movement. However, kudos to those who accomplished such a feat: I was never successful producing such a joint under even most perfect circumstances, and these joints are expected to be narrow, while in order to be given a chance to work, they would need to be approx. 1" wide. Most joints of this kind would require a different approach: e.g. face-adhering a silicone tape instead. Such tapes appeared on market shelves years ago, the trouble is that their adhesive often fails prematurely.

General advice: do not buy anything that is on shelves of home improvement stores. This is one of the few construction materials that seem to be seriously underserved in that respect. Buy at specialized stores or online. You would be surprised and happy that you do: most professional sealants don't cost much more, and perform much better. When you do, it's best to get 600ml sausages – they offer the best bung for your buck, and chances are they would come relatively fresh, as contractors generally only use them, and there is a sufficient turnover at warehouses. See also my notes about differences between sausages and tube cartridges above.

Most so called professional-grade construction sealants are not really so professional. They typically trade their ease of use for their performance. E.g. most of them are one-part systems for ease of use. They seldom come with any choice of default primers, for the same reason. Factories and real professionals use a completely different stuff, but the technological regime and the know how required for such applications make it seldom practical for construction contractors, much less for DIYers.

What sealants to use. Among silicones, Dow Corning 700's series set the golden standard in the industry, particularly the 795. 790 comes with better movement capability (50/100 meaning it could half-compress and stretch twice) and is best for precast concrete, EIFS, and similar easily stainable porous materials, 786 for bathrooms. Alternatives include BASF, Bostik, Tremco, Soudal, Pecora, and Sika, that also produce butyl sealants. Also, there are many boutique brands, particularly in the waterproofing, roofing, and glazing industries, with each manufacturer recommending their own labels to seal their other products. These brands unfortunately are sometimes reluctant to support you, when it comes to sealing their competitors' products, that may interface with their own products. You would need to test them yourself.

Poorly designed moving joints, such as flat flashing and coping joints, etc. are generally best addressed by butyl sealant or dedicated preformed gaskets or combination of both. Butyl is one of exceptions to the Class 50 rule I gave earlier, but it does not matter because it does not fully cure, besides butyls are exempt from ASTM E920 reporting. Butyl does not harden – it remains elastic, and therefore should be used in narrow waterproof flashing and coping splices, and similar moving joints, and in very thin applications, e.g. squeezed between two moving metal sheets, punished by shear forces. It could also be obtained in form of preformed tapes. In my practice, it's my favorite go-to sealant type. It's hard to screw up, unless you use it on wide precast panel joints. This stuff is used in an average cars and trucks to seal body joints.

Be wary of sealants that are also advertised as adhesives. Most adhesives seal water, so they are justified to be also called sealants, but they are seldom elastic enough, because allowing a significant deformation is not necessarily a desired property for a glue. Some polyurethanes are sold as such.

How to apply them: there are excellent manuals available online, such as Dow Americas Technical Manual. Search for "sealant technical manual" and similar keywords online. My favorite application method is a "dirty finger application": I run my finger (in a rubber glove) along the bead of sealant three times: first time against the direction of the nozzle, then follow the nozzle, and back again. This assures tooling the sealant into a crack, in spite of irregularities of the surface. Professionals use a polished stainless-steel spatula instead.

Previous Attempts. SWRI Certification.

If you are still confused, you are neither the first nor alone. E.g. a nonprofit SWRI Sealant Validation Program was created to eliminate the confusion created when trying to compare product data reported by competing manufacturers. The sealant must pass ASTM C719, C794, and C661 testing, for adhesion, cohesion, and hardness. Look how short is the list of SWRI-certified sealants: https://www.swrionline.org/currentvalidatedproducts It's a good starting point to search for your sealant. And, sadly, generally none of these sealants you can normally find in a supermarket.

Most typical applications:

Domestic glass pane replacement. This typically requires a combination of two materials: a two-side adhesive tape (e.g. 3M) for bonding and joint proportion-setting, and a silicone weather sealant (e.g. DC 795) for UV and weather resistance. The sealant may also be used for bonding, with a different device used to control the joint depth and width.

Gutters, flashings, metal coping, etc. These materials move a lot. A splice of a10 ft long aluminum gutter is expected to move at least 3/16, and if these splices are fastened together, these movements will add up at their ends and corners. Only butyl sealant should go into these splices or gasketed connections made with serrated rubber sections. It they are fastened directly through waterproofing and roofing membranes, to add insult to injury, these holes would soon be elongated. Again, a butyl sealant into these holes would be the best bet as a quick band-aid, but there are some incompatible membranes.

Exterior mortar, stone, and concrete joints: Dow Corning 790 in a double-stage configuration (the trouble with sealing porous materials is that they are porous, so your single-bead joint is only as good as the water resistance of the adjacent ¼" deep concrete or masonry strip, which only takes seconds for water to infiltrate based on the typical water spray testing.)

Wider joints are best packed with preformed expandable seals with strippable adhesive sides. They typically have an accordion-like section, promoting movement capacity, as their typical application is structural expansion joints.

Typical roofing penetration, e.g. solar rooftop array mounts, etc: Best to consult the specific roofing manufacturer, as there is a large variety out there. E.g. the typical SBS membrane by Tremco, comes with TremSEAL Pro polyurethane sealant. Other, independent options exist for those who are either advantageous, or when the original manufacturer could not be determined: e.g. BASF's NP 1 and STS GreatSeal PE-150 are sometimes a good choice on PVC roofs and vinyl trim. If still in doubt, I would use butyl and create a compression joint elevated above water line, with butyl below a large base plate. This is a proven design, utilized in many good roofing penetrations e.g. for solar racks.

Other Aspects.

The subject is so broad, that it's hard to begin. Obvious approaches would include a gallery of failures, a gallery of testing methods, a gallery of Dos and Donts, choice of tools, choice of specifications, etc. You decide: I only have so much time. All the photographic materials are there, somewhere on my hard drives, as well as an applicable literature, specs, and even videos. Send me an email.

Available Information.

The good news is that all the necessary information is already available to the public. Manufacturers are doing a decent job, not only publishing technical guidelines, and educating through seminars, but also some provide convenient adhesion testing services.

The bad news is there is plenty of misinformation and drivel available to the public, and it's hard to tell one from another. Even the mainstream media lie. I remember responding with some irritation to an article titled "*Expert Guide for Choosing the Right Caulk*" in "Family Handyman" penned by Mark ***** in early 2018. My critique popped up in my email search recently: here are some lines I wrote to him: *the article is both somehow limited and claiming unnecessarily broad coverage. There is so much that isn't said: elasticity, durability, application, compatibility, and just the basic instruction how to read the "nutrition facts" label on the sealant cartridge. Caulking became a universal panacea in construction, while almost no contractor (much less a homeowner) does it right. It's like a plaque, and there is so much improvement to be made for common good. Although, I admit, my perspective may be skewed after 20+ years in the façade engineering and diagnostics.* The author and the magazine responded kindly to my critique and asked if I would be willing to write for them. I didn't have time to write till now. However, by that time, Mark ****** no longer worked in "Family Handyman", and the new assigning editor, Mr. Berit ***** did not care to publish my follow up article about sealants. Therefore, their readers would remain condemned to incorrect information and data, as almost everything that "Family Handyman" published in this article was dead wrong.

The good news is there are whole books written by folks who know this stuff, e.g. Michael Kubal and Edward M. Petrie. Bad news is that the best tend to be long and expensive (765 pages and almost $400 price tag) and focus on industrial solutions and "new" applications. Again, the bad news is that few contractors ever care. Example: on a recent multimillion facade job, one of the largest in the country, where I was a building commissioning expert, only few substrates were lab tested prior to the installation, and it happened after four years of nagging, after first failures popped up in areas built previously.

The other bad news is the construction industry's obsessive overreliance on sealants. They are just bad news for maintenance.

Tools.

Power caulk gun is an improvement over a hand tool in two ways: it produces a consistent bead of sealant, and reduces finger strain in case of hard sealants (although if your sealant is so hard to pump manually, or if it oozes back into the plunger, your sealant is probably not good any more, and you don't need a new gun, you need a new sealant instead, and a better way to store half-used cartridges). Instead of getting a power gun, consider a better storage of cartridges: each should be individually and tightly packed in polyethylene (shopping) bag, and its nozzle should be cut in a repetitive way and plugged with dedicated plugs. I typically also wrap the tip in a rubber glove that I used for the caulking operation and tie it. Large 600ml sausages last longer than 300 ml tubes, because they are fully wrapped in metal film, keeping them reliably sealed from atmosphere, so if you are in this business, get a 600ml gun.

Most such tools are heavy, e.g. ~ 6 lbs, plus the weight of the sealant cartridge, and therefore it is hard to apply by one hand if you are doing it for an extended period of time. Most competitive tools on the market have similar issues, because this niche market is simply not very developed.

Photo above. This is a (brand name) power caulk gun. I got them for $40 apiece, because I am cheap. This tool weights almost 6 lbs, plus the weight of the sealant cartridge, and therefore it seriously strained my tennis elbow. It has a very hard trigger that requires almost the same force as pumping a trigger of a regular ratchet gun. To add insult to injury, it lets the plunger retract and release the pressure after the trigger was released, and doesn't advance the plunger quick enough in the beginning, so getting the sealant flowing again at the typical, lowest flow setting requires too a long a wait to make it a practical tool for the typical, repetitive caulk job. I guess it was a feature intended to prevent sealant dripping out

of the nozzle, but it backfired. The trigger comes with a safety, but does not have any flow adjustment, there is a separate slider instead, and it's designed in such a way, that it's quite challenging to adjust with one hand, quite unergonomic, and completely impossible if you are left-handed. The adjustment does not have enough coverage in the slow settings range, so your choice is limited to slow, too fast, very fast, excessively rapid, and insanely quick discharge… It does not have a hook, so it keeps falling off a ladder. Storage of empty tools is challenging, as there is no fast forward or release setting to push the plunger to the front at the absence of a cartridge, but that's probably what the insanely fast setting on the slider was intended to, but there should be a separate release, while the slider should focus on slow settings instead. Neither is there are plug or cap to temporarily close sealant nozzle when stored with a cartridge. Now, to be fair, most competitive tools on the market have similar issues, but cost ten times more. This market is simply not very developed.

Photos above: If you are an average homeowner, you just keep re-sealing many feet of the same old cracks in stucco and around openings, that keep splitting, no matter what. The right way to seal them would be to install a bond-breaker in the middle of a crack, to give the sealant a chance to stretch, (but who has enough time for that?). Also, the practical choice of paint color is sometimes dictated by the available sealant color range. If you rely on a local supply store, it would be typically limited to white and clear.

Good independent sources:

Handbook of Adhesives & Sealants by Edward M. Petrie https://www.amazon.com/Handbook-Adhesives-Sealants-Edward-1999-10-11/dp/B01FJ0NWSC

Construction Waterproofing Handbook https://www.amazon.com/Construction-Waterproofing-Handbook-Michael-Kubal-dp-0071489738/dp/0071489738/ref=dp_ob_title_bk

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