June 3, 2019

Today I spoke with our Slovenian client, a major energy facility, purchasing department. During the annual overhaul, they did not decide to change the platinum elements, although I also communicated the story below personally. "It's too expensive, we save at every step".

*I don't want you save money where it is not possible, we don't want to be the only ones who know this story. I want you all to know it, so that together we can create real savings, not sparkles, but real financial effects of thousands of euros and in fact have a positive impact on your **ENERGY EFFICIENCY**, on yours and ours **ASPECTS OF SUSTAINABILITY**, on **LOWER CARBON EMISSIONS**, on **LOWER COSTS** of new thermocouples, to **LOWER WORKING COSTS**, to a **LONGER LIFETIME OF FURNACES and INSULATIONS** and to effective temperature **CONTROL of the QUALITY** of your products.*

Correct use of platinum (and other) thermocouples and energy efficiency

Industries containing processes at high temperatures often use platinum thermocouples (S, R and B type) to measure the temperature, if it is higher than 1100 °C and/or nickel-chromium (K type), when the working temperature is up to 1000 °C or maximum up to 1100 °C. In this article, platinum thermocouple is the general name for platinum-rhodium combination thermocouples, standard EN 60584 (type S, R and B).
Platinum and rhodium are rare precious metals that are obtained through a complex and expensive process, which is why they are more expensive than gold. They have excellent thermoelectric properties, which are used to measure temperatures up to 1800 °C, as a thermocouple usually measures between 1100 °C and 1700 °C. At first glance, and for the average user, it is an expensive "measuring sensor", since on average we are talking about prices of several hundred euros for one thermocouple. Therefore, the purchase and replacement of platinum thermocouples is always a hot debate between the maintenance and purchasing departments.

But that must not be the case. Why?

Let's look at some theory.
Only raw material of the purest form is used to produce platinum wire (one wire is pure platinum (Pt), the other wire is platinum with added rhodium (Rh)). Depending on the amount of rhodium in the alloy, thermocouples are classified as S, R or B type.
Platinum wires are laser-welded and encased in a protective rod and a closed tube - one, two or three (usually all C799 ceramics). Namely, platinum is atmospherically unstable and attracts compounds from the surroundings. These chemical reactions cause a change in the thermovoltage, so any contamination or unprofessional use of platinum thermocouples has a great impact on the accuracy of the measurement. For correct and long-term use, it is necessary to take into consideration the following factors of use:

1. pollution by chemical vapors

Vapors from metallic and non-metallic surfaces condense on the surface of the thermocouple, if the measurement is performed without ceramic protection of the thermocouple, or if the ceramic is of poor quality. Due to high temperatures, chemical vapors are dispersed on and into the surface of the wires because of which the thermal voltage changes and the accuracy of the thermocouple decreases.

2. reducing atmosphere

Atomization of platinum occurs in a reductive atmosphere, which reduces the lifetime of the thermoelectric element and its accuracy.

3. pollution with organic compounds

Organic compounds decompose due to heat and create the phenomenon of reduced atmosphere.

4. choosing the right type and diameter of the thermocouple

The choice of the optimal type and diameter of the thermocouple depends on the actual temperature of the process, the atmosphere and the desired lifetime, accuracy, and sensitivity of the thermocouple.

5. long-term use

In accordance with the phenomena described above, there is a gradual decrease in the value of the thermoelectric voltage in platinum thermocouples that are exposed to high temperature for a long time. This is caused by the diffusion of rhodium into the platinum. Unfortunately, this phenomenon cannot be prevented, **so platinum thermocouples must be regularly checked and replaced.**

Since I am not an expert in physics and chemistry, please allow me to use Wikipedia, which in my opinion user-friendly explains, what atmospheric reduction is:

Reducing atmosphere

*A **reducing atmosphere** is an **atmospheric** condition in which oxidation is prevented by removal of oxygen and other oxidizing gases or vapors, and which may contain actively **reducing** gases such as hydrogen, carbon monoxide, and gases such as hydrogen sulfide that would be oxidized by any present oxygen.*

But what does this mean in practice?

1. **The accuracy of platinum thermocouples decreases with use, permanently and irreparably.**

   Example: the set temperature of the furnace is 1350 °C, we check and measure for example 1349 °C with a reference standard, but our built-in and already unstable thermocouple only gives 1300 °C. Of course, the regulation wants 1350°C, so it raises the actual temperature to almost 1400 °C to meet the regulation's requirements. The result: because of an unstable thermocouple, we heat 24 h/day 50 °C more than necessary, thereby further damaging the thermocouple, the furnace, the products and wasting a lot of energy. **Can you calculate how much energy (electricity, fuel, oil, gas, coal...) this means in your case? This is worth calculating and presenting as an extremely effective argument for energy efficiency and regular replacement of platinum thermocouples**. And let's not forget 50 °C today can be 60 °C tomorrow... the error can grow very quickly.

2. Experience shows that at a temperature of up to 1300 °C and a correct design, the thermocouple works optimally from 6 months to 1 year. Then the measuring part must be **replaced. If correctly designed, only the insert of the thermocouple is changed.** This exchange is difficult to explain to the superiors because the element usually has no visible damage yet, it works, the system shows the temperature satisfactorily. Let's not forget that every day more energy is wasted, than the cost of such thermocouples! **It's not just our experience, it's many years of experience, which is why regular replacement of thermocouples is already incorporated into newer aviation and automotive standards known as CQI directives**. This is not inventing hot water; this is a fact.

3. Platinum thermocouples should be checked monthly with a reference standard that we have only for this purpose (we never compare one working element with another working element!).

4. For temperatures higher than 1300 °C, we use a platinum wire with a diameter of 0.5 mm; for lower temperatures, 0.35 mm is sufficient (there is often an adjustment from 0.5 to 0.35 mm due to price, but BEWARE!).

5. The platinum must always be additionally protected with a ceramic tube of type C799 (more expensive than C610, but less permeable, here as well are frequent price adjustments, but BEWARE!), or another tube that does not evaporate compounds at high temperatures (special forms of glass, etc.).

6. **All replacements, tests, calibrations, and purchases are much cheaper than losing energy due to a bad thermocouple.**

7. This is physics and there is no protection to prevent this phenomenon, so regular checks and changes should be considered.

8. To save money, it happens that the user or a bad supplier uses old wire for new thermocouples. This is complete madness and inappropriate. For me, this is a crime, because with a lower purchase price, you are robbing the client of many energy euros. I point this out because this is what is happening. Cheap providers do this. When the client says that our temperature sensor is 50 % more expensive than another provider, I immediately know what time it is.

9. **Subscribers who reduce costs when purchasing platinum thermocouples increase their own energy costs exponentially. I state that the cost of purchasing a platinum element only occurs the first time. Everything else is energy efficiency and the best possible!**

10. Platinum has perfect recycling characteristics. Here it depends, whether the manufacturer buys it back or not, because this is costly, analyzes are expensive. At ELPRO LEPENIK, we extract the old platinum from used or damaged elements and charge it by the old-for-new system, for client's benefit, immediately upon execution of the order. We collect the platinum for a while, then return it directly to the producers for analyzing and processing. We often achieve extremely favorable analysis results, with losses of only around 2 %, meaning that 97-98 % of the returned platinum comes in the new certified pure alloy. Basically, it is a stock market buyout and a stock market purchase with analysis and processing costs, but such an explanation argues the effect. We succeed in this because we teach our clients the appropriate use of platinum thermocouples and thereby achieve the best possible energy and financial effects for the client, for us, the producers, and the Earth.

11. Through the purchase of old platinum, we directly reduce client's cost. PLATINUM IS A RARE METAL; HELP US PRESERVE OUR BLUE CRADLE AND ENOUGH RAW MATERIALS FOR NEW GENERATIONS. Collect platinum and return it for redemption, this is also the most cost-effective way.

DO NOT SPARE BY NOT CHANGING HIGH TEMPERATURE THERMOCOUPLE (neither platinum nor nickel). THIS WILL NOT SAVE YOU. IN FACT, YOU ARE ALREADY USING MORE ENERGY THAN NECESSARY AND IT'S GETTING WORSE DAY BY DAY - YOU WILL SPEND A LOT MORE MONEY!

Although this is a topic to write about, let it be enough for this contribution. I think I've covered the essentials without embellishment. I hope that the contribution will find its way to users, buyers, and decision-makers. It is very important that a wider circle is aware because it involves aspects of measurements, regulation, accuracy/calibrations, maintenance costs, procurement costs and most importantly - energy costs.

prepared for you by Aleksandra Lepenik

Rogoza, December 6, 2017, revision June 3, 2019, revision May 11, 2022, correction "reductive atmosphere" June 10, 2022

P.S. Aleksandra, I am an expert in the field of temperature measurement and calibration at ELPRO LEPENIK & Co. I have more than 25 years of experience in the field of industrial temperature and relative humidity measurements, supported by the management of quality systems, including our accredited calibration laboratory. But I'm still a layman and I learn something new every day. I regularly analyze the results of our production, the results of users, the results of calibrations and research phenomena and materials for temperature measurement. It is especially with great pleasure that I listen to users every day and give advice on this and similar topics. It's nice when a person likes what he does and even nicer if he's willing to share it with others ☺