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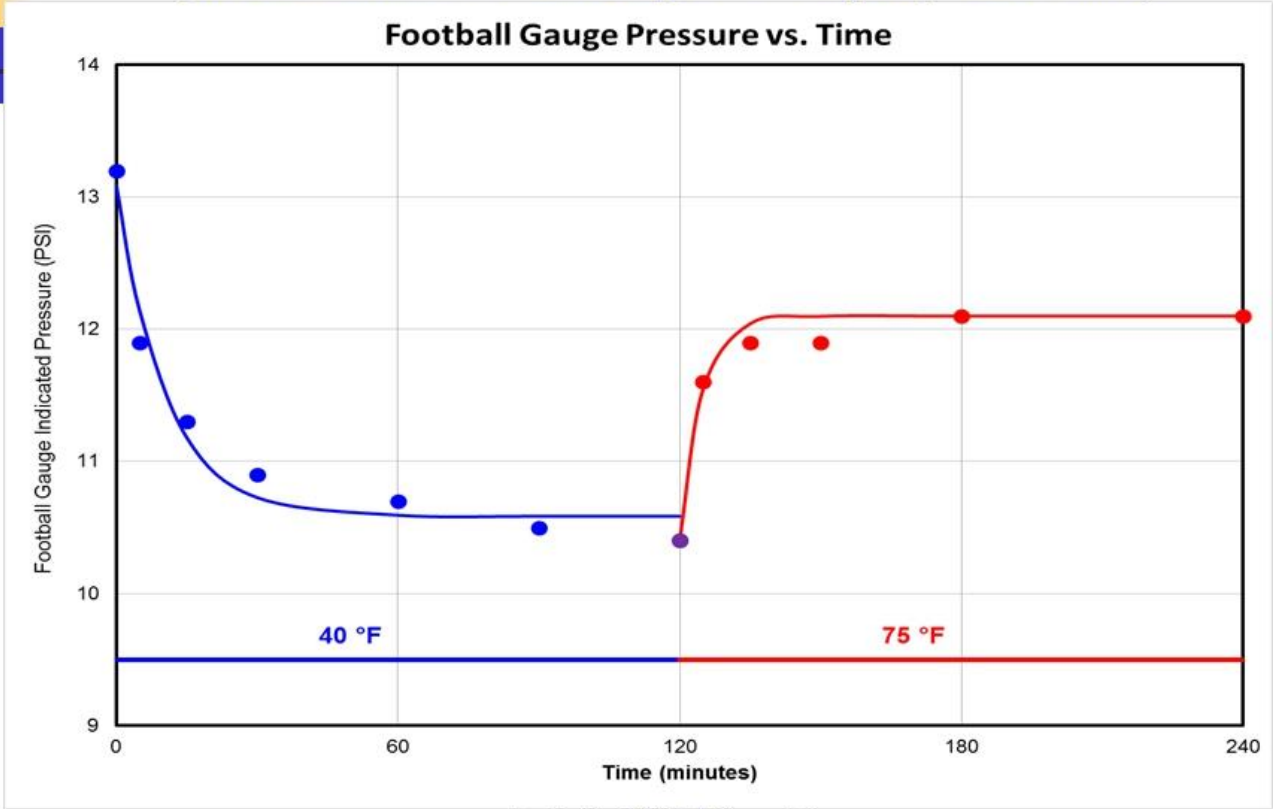
Topic: "An Investigation of Fill Pressures and Deflated Footballs"

Executive Summary:

- **The Analytics & Metrology department is particularly well suited to investigate the fill pressure of a football and the influences that could affect the fill pressure because it is a well-equipped laboratory with the needed instruments and measurement equipment and is an ISO 17025 accredited laboratory. Documents made available to the public by the NFL do not mention any laboratory engaged by the NFL that has such an accreditation.**
- **The comparison between the measurements using a typical football inflation gauge and the highly accurate instrumentation used for fill pressure measurements at ANM found that both devices agreed to within +/- 2 % when measuring absolute pressures above 1 atm.**
- **While measurement values using the same inflation gauge (e.g. the one initially used to inflate the balls) were found to be repeatable within +/- 2 %, if a different inflation gauge (e.g. that of an official during a game) is used the deviation could be as high as +/- 7%, which is not within the NFL allowable range.**
- **Using the environmental cold chamber of ANM, it was determined that a football inflated to 13.2 psi (at room temperature of 75 F) dropped to a fill pressure of 11.9 psi after only 5 minutes of exposure to an ambient temperature of 40 F . This value is outside the NFL allowable fill pressure range of 12.5 to 13.5 psi (13 psi +/- 3.8 %).**
- **To assess whether it is possible to determine the change in fill pressure of a football without the use of a needle gauge (which can be assumed to always result in some air loss each time it is used), our testing also included the weighing of the football. These measurements determined that a weight change of 0.25 grams was associated with a change of 1 psi inflation pressure. This finding was also confirmed by using the ideal gas laws (e.g. Bolye's and Charles' Laws) to calculate the weight of air for a 1psi difference.**
- **If a football is weighed when properly inflated, it will weigh the same under all temperature conditions, whether at 75F or 40F, it is only the fill pressure that changes with temperature.**
- **To determine whether the type of gas (which is not specified by NFL rules) used to inflate the football would have a noticeable effect on the football, helium was used to inflate a football and it was determined to reduce the total weight of the football by ~ 1 %. Of course a heavier gas such as xenon would result in a heavier football weight.**
- **Other influences that could change the fill pressure, such as the pounding that a football takes during the course of a normal game, were also studied. However, the limited number of tests did not result in a measureable effect being detected.**
- **Considering all of the testing that was performed, it seems obvious that the most dominant effect on the fill pressure in a football is the temperature difference between the ambient temperature (when initially inflated) and the temperature on the field when the football is being used.**

Football Pressure and the Cold Chamber

(uncorrected for Leakage <= 1 psi / 120 Min.)



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