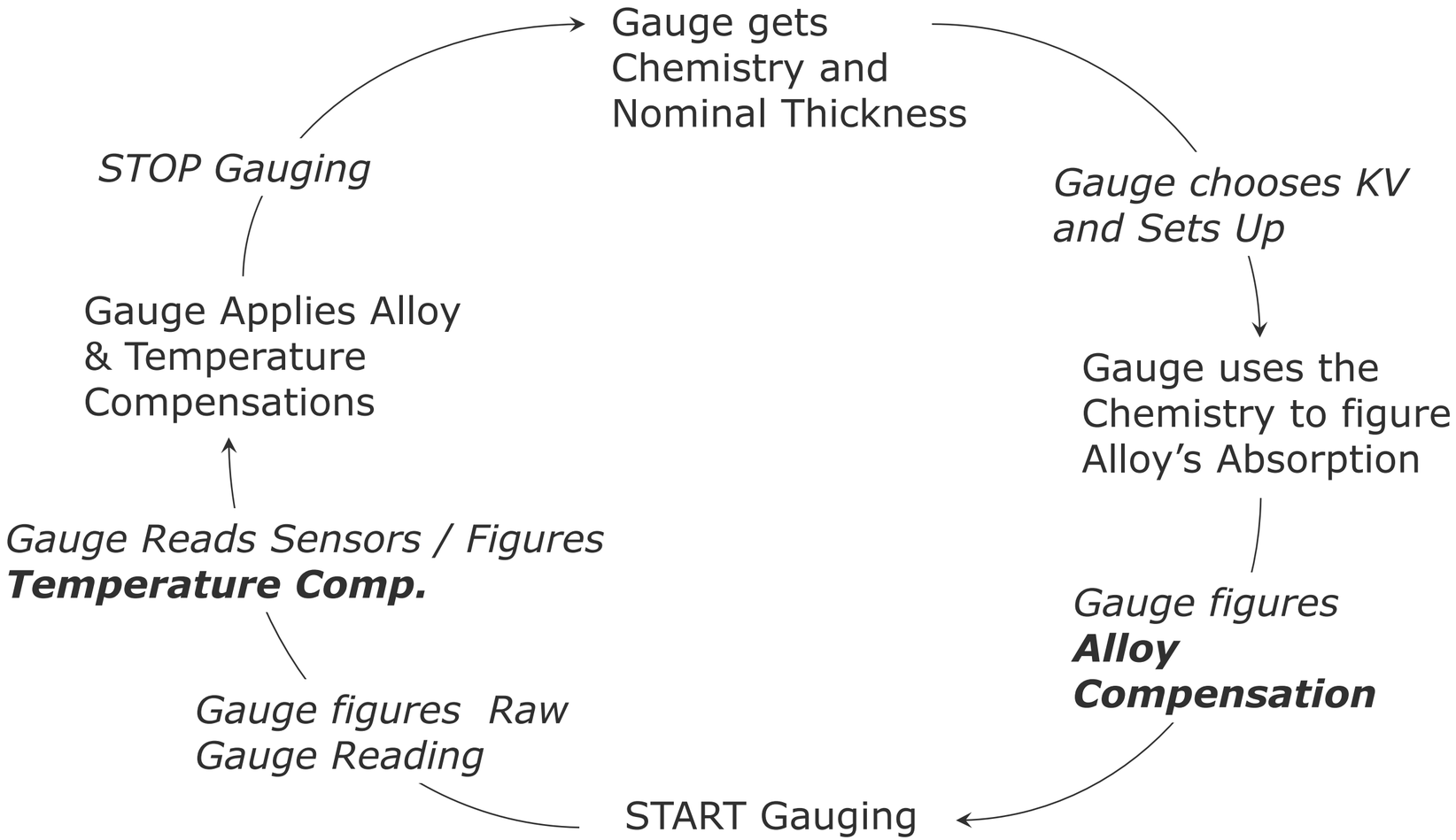
GlobalGauge CORPORATION

Alloy & Temperature Compensation

Global Gauge Corporation | Compensation Factors

Gauging Cycle & Compensations



Alloy Compensation

- A Material's Elemental Chemistry can be used to create Alloy Compensation
- Precisely measured samples can also be used to create Alloy Compensation
- A combination of both methods can provide the benefits of both
  - Real-world samples can correct for errors in elemental method
  - Elemental method can provide real-time coil-to-coil corrections

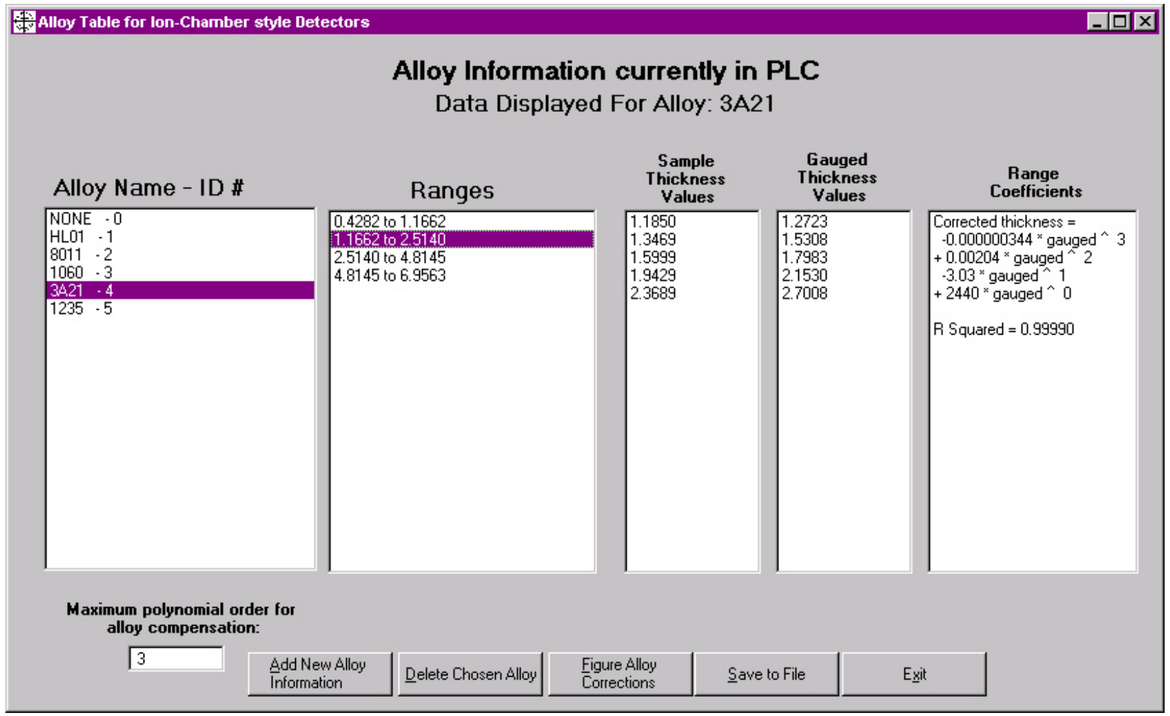
Alloy Compensation

- X-Ray gauging systems are impacted by the elements in the material being gauged
- An element’s %-by-weight in the alloy, density and Absorption Index (coefficient) all play a part in affecting x-ray passing through the material
- Example for a Sample Material:

Element	%-by-weight	Density	%-by-absorption
Iron	96 %	7.9	93.1 %
Molybdenum	2 %	9.0	6.5 %
Silicon	2 %	2.3	0.3 %

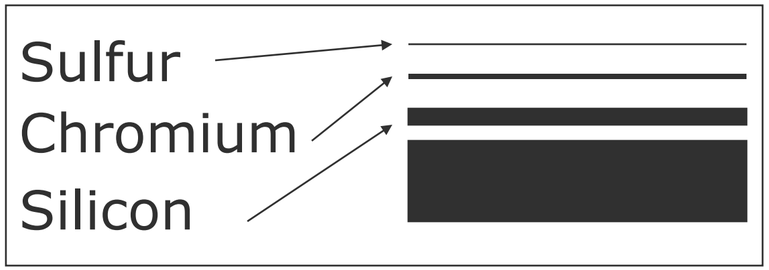
Alloy Compensation: Samples Method

- Samples of known thickness can be used to enter Alloy compensation information into the gauge
- Gauge Software provides step-by-step guidance



Alloy Compensation: Elemental Method

- The Elemental %-By-Weight Determines a Material's Absorption Coefficient
  - This is dependent on the Energy of the X-Rays
  - %-By-Weight is Modeled as %-By-Thickness



- The Alloy's absorption is compared to the Magazine's absorption to create a compensation, which is applied to the gauge reading

Alloy Compensation: Math

- Alloy Compensation Math involves values that are Energy-Dependent (E) and Element-Dependent $_{Element}$
  - Alloy Sample Thickness t_{Alloy}
  - X-Ray Intensity $I_0(E)$ enters sample and exits with Intensity I
  - MAC(E) $_{Element}$ is an Element's Mass Attenuation Coefficient
  - $\rho_{Element}$ is an Element's Density
  - %weight $_{Element}$ is an Element's %-by-weight within the Alloy
- The Intensity equation is solved for both the Magazine Material and the Alloy Material

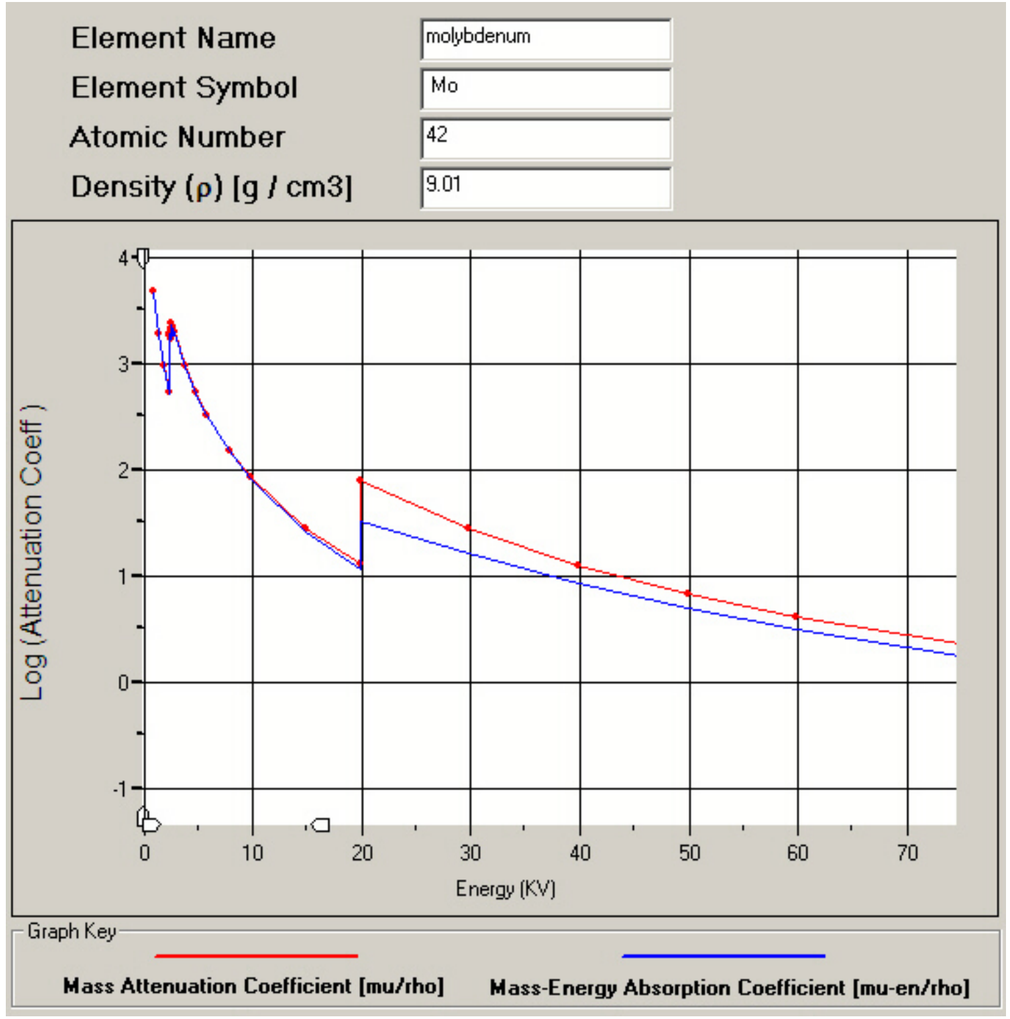
$$I = \int_{Energy\ E} \{I_0(E) \cdot \exp[t_{Alloy} \cdot \sum_{Elements} (MAC(E)_{Element} \cdot \rho_{Element} \cdot \%weight_{Element})]\} dE$$

  - The two equations are compared to determine an Alloy Compensation to apply to the gauge reading

Global Gauge Corporation | Alloy Compensation

Elemental Absorption (Molybdenum)

- Some element absorption is impacted by Atomic Absorption Edges
  - Sizeable difference in absorption for a Small difference in KV due to the atom's Electron Shells



Temperature Compensation

- As a material's Temperature increases, the material expands, getting thicker / increasing in volume
- Increased volume means lower density, so an X-Ray gauge reads too Thin → $t_{Gauged\ hot}$
- This change can be compensated-for so the gauge displays the thickness → t_{cool} that the material will be after it cools

Temperature Compensation: Math

- Temperature Compensation
  - When material is hot, its **actual** thickness (as would be measured by a contact measurement) is expanded by an amount based on material's expansion coefficient α, which is itself a function of Temperature (T)

$$\Delta t = T \cdot \alpha(T)_{Element} \cdot t$$

  - Thickness when cooled t_{cool} depends on the gauge reading on hot material $t_{Gauged\ hot}$

$$t_{cool} = t_{gauged\ \ Hot} \cdot (1 + Dev.Scalar)$$

  - Dev. Scalar is a function that depends on Temperature T, and coefficients A and D which vary for different Temperature Ranges (T)

$$Dev.Scalar = A(T) \cdot T + D(T)$$

Temperature Compensation: Math Example

GGC Hot-Mill Temperature-Compensation Data

Gauged-Hot Thickness = 1.0000 mm
Deg C = 1250
(Deg F =) 2282

Dev. Scalar = 0.0282075

0.00002025	A
0.002895	D

Expansion "Coeff. #"	Expansion Coefficient per deg C	Deg C	"Hot" thickness Change	Actual "Hot" thickness (contact mic)	Actual Cooled Thickness Tcool
11.85	1.185E-05	1250	1.523E-02	1.04344	1.02821

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Thank you!

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