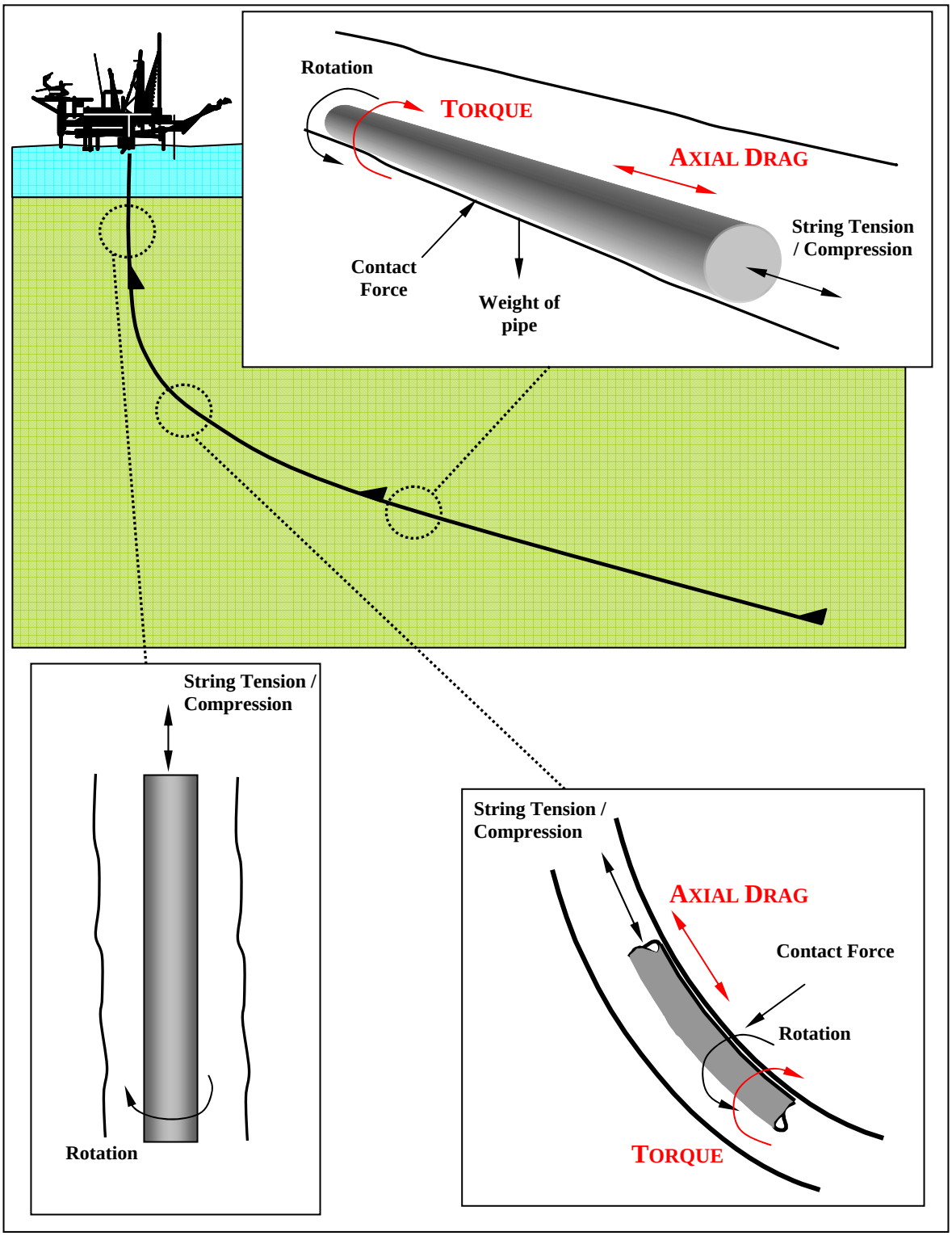
Attachment E: Torque and Drag in ERD Wells

Source: K&M Technology Group, *Drilling Design and Implementation for Extended Reach and Complex Wells – 3rd Edition*, 2003.



Drillstring Forces in the Wellbore

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Modeling Torque and Drag – Friction Factors

In an ERD well environment, a friction factor really isn't purely a friction factor at all. It is more of a "fudge factor" because it is used to account for a number of things in addition to friction, including:

- Mud system lubricity
- Pipe stiffness
- Cuttings beds
- Key seats
- Stabilizer and Centralizer interaction
- Differential sticking
- Dogleg severity (known and hidden)
- Hydraulic piston effects

It is important to note that slack-off, pick-up and torque friction factors are not the same, although they might appear to be so in nature. Often, the industry will only publish a single friction factor for a given hole section. In fact, most torque and drag models only allow for the entry of a single cased hole and single open hole friction factor. ***To accurately model torque and drag, separate friction factors are required for slack-off, pick-up and torque.***

The majority of torque and drag prediction software models the string as a "flexible member" where pipe stiffness is not accounted for (i.e. soft-string model). The string is modeled as a string or cable that is capable of carrying axial loads, but not bending moments. In this case, the pipe stiffness is accounted for by increased friction factors. Hence, casing will have higher friction factors than will the more flexible drillpipe. Further, large OD drillpipe will have larger friction factors than will smaller OD drillpipe. It is important to remember that friction factors are not necessarily inter-changeable between software programs. The non-dimensional friction factor that is calculated by one software program may be different for other programs.

Furthermore, it is important that the software is well calibrated with field results, and that the program user is not only familiar with the software, but also the realities of drilling, casing and completion operations.

Friction Factors for ERD Well Planning

Like any offset data, it is important to ensure that the data is relevant. It is not advisable to use a friction factor for planning assumptions unless the background of the information is understood.

As a minimum, the following must be asked of any offset friction factor data when planning an ERD project:

1. Are the quoted friction factors relevant for the software model that you are using? Different models use different algorithms, and therefore the resulting friction factors may not be the same for each model.
2. Were the drilling fluids the same?

3. Is the lithology the same? Different rocks have very different friction factors. For example, clay can have exceptionally low friction factors, while limestone or sandstone can have quite different values.
4. If drilling in a reservoir section (for example, in a horizontal well), has the over-balance pressure and subsequent differential sticking forces been considered? Differential sticking will show up as increased friction factor.
5. For casing runs, is the centralization similar? Friction factors are quite sensitive to casing centralization type, placement frequency and overall number.
6. How valuable is the offset data? Shallow and low angle wells (or sections thereof) often produce spurious and unreliable data. This is because the accuracy that the driller can read the weight or torque indicator is much less than that required to provide meaningful results. Furthermore, are the open hole friction factors based on a significant open hole interval, or simply a short open hole section below a very long cased hole interval? Again, the data can be misleading.
7. Were lubricants in use?
8. How good was the offset hole cleaning ability? A clean hole will have lower friction factors than will a dirty hole.
9. Is the drillstring or casing diameter similar?
10. Friction factors back-calculated through a flexible string model from gathered field date are only indicative of those that should be used for planning purposes. Planning friction factors must be back-calculated using actual data in a "planning model" (i.e., model with a smooth wellpath).

Once all of this data is taken into consideration, it is still advisable to obtain the raw data from the offset wells and to process it to come up with friction factors from the model that you will use for planning.